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STUDY OF SOLID WASTE MANAGEMENT PRACTICES IN THE PULP AND PAPER INDUSTRY

GORHAM INTERNATIONAL, INCORPORATED

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This report investigates and identifies present solid waste management practices, examines alternatives, and develops strategies for future pulp and paper industry waste management. It examines waste management in five major segments of the pulp and paper industry; pulp mills, paper mills, paper board mills, and de-inking mills. Data is presented on pulp and paper industry solid waste generated since 1960. A case study for each of the five major pulp and paper manufacturing segments is presented.

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PREFACE

This report on solid waste management practices in the pulp and paper industry was prepared by Gorham International Inc. pursuant to Environmental Protection Agency contract 68-03-0207.

The statements, findings, conclusions, recommendations, and data in this report are not necessarily those of the Environmental Protection Agency, nor does mention of commercial products imply endorsement by the U. S. Government.

Gorham International Inc. wishes to express its appreciation to the EPA project officer, Alfred E. Lindsey, Hazardous Waste Management Division, Office of Solid Waste Management Programs, for his valuable suggestions, review advice, and encouragement throughout the contract efforts. We also wish to express our thanks to the pulp and paper industry companies, associations, and institutions that willingly supplied data, information, and comments relative to our study objectives.

Specifically, we want to acknowledge the following companies that cooperated fully with our personnel in carrying out the case study efforts:

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Naheola, Alabama

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Millinocket, Maine

Mead Corporation, Mead Papers Division
Chillicothe, Ohio

Owens-Illinois, Forest Products Division
Valdosta, Georgia

This study was performed with generous cooperation from the pulp and paper industry to provide an overall review of the industry's solid waste management systems and problems. It is intended as a guide for everyone interested in pulp and paper industry solid waste management activities. It is hoped that it will be of assistance to the industry in its continued efforts to improve solid waste management operations.

CHAPTER I

INTRODUCTION

The pulp and paper industry occupies an important position in the United States society. Paper products are widely used in all sectors of the economy on a daily basis.

Because of the industry's large production (50 million metric tons - 55 million tons in 1971), it was included as one of the industries to be studied relative to solid waste management practices and procedures. Prior to this time, the industry's solid waste management activities had not been viewed as a single entity, and the small amount of available information dealt with specific cases and was scattered throughout the trade literature. Thus, this report brings together a body of knowledge on pulp and paper industry solid waste management activities for the first time.

Many specific areas have been dealt with on an abstract basis simply because quantitative data is not available, even within the industry. Operating mills maintain their cost accounting systems consistent with production activities and not to pinpoint waste management data. Also, because no value is traditionally assigned to solid waste, many solid waste material flows are unmeasured and must be determined by calculating losses based on known inputs and outputs. However, by conducting five case studies of representative integrated pulp and paper mills, much valuable background data was accumulated. Additionally, industry contacts and representatives provided available data and observations on the industry's solid waste management practices.

The basic project objectives which this report addresses are:

1. To provide a comprehensive assessment of the solid waste management practices and problems associated with the pulp and paper industry.
2. To evaluate and assess the legal and economic impact that present and proposed Federal, state, and local environmental regulations and legislation may have on pulp and paper industry solid waste management.
3. To identify, analyze, and evaluate alternatives to those pulp and paper industry solid waste management practices that are currently insufficient or that may become inadequate as a result of tightening environmental regulations and legislation.

4. To provide recommendations of alternative strategies and techniques for improved solid waste management planning, implementation, and operations in the pulp and paper industry.

CHAPTER II

SUMMARY

Based on its important role in the U. S. economy and its large tonnage production, the pulp and paper industry was selected as a subject industry for the Environmental Protection Agency's solid waste management studies.

The study was designed to provide background information; to estimate past, present, and future solid waste quantities; to evaluate the impact of environmental legislation; to evaluate the industry's solid waste management technology; and to provide recommendations for alternative management techniques.

To provide sufficient background and understanding of the industry, the pulp and paper industry structure, major product categories, production processes, and production data were compiled.

Actual solid waste generation within the pulp and paper industry results from a limited number of specific sources. Several of these sources are common to most industry facilities with other sources being specific to particular industry segments or production processes. The sources common to much of the industry are wood processing, power generation, personnel activity, manufacturing services, and wastewater treatment. The more specific sources are wastepaper reclamation, chemical pulping, specialty products, groundwood production, and residuals handling loss.

Wood processing is the largest single source consisting primarily of bark and associated wood wastes. Power generation results in major solid waste quantities where coal is burned while bark ash adds smaller solid waste quantities where energy recovery from bark is practiced. Personnel activity solid waste consists primarily of lunchroom, cafeteria, and general work area waste while manufacturing services solid waste comes from shops, warehouses, shipping/receiving departments, garages, and other industry support services. Wastewater treatment is a rapidly growing solid waste category consisting of primary and secondary wastewater treatment sludges.

Wastepaper reclamation generates solid waste consisting of the large variety of contaminants present in incoming wastepaper supplies. Chemical pulping solid waste comes primarily from the recovery operations where inert material and nonreacted chemicals are removed during cooking liquor preparation. Minor specific sources of primarily wood waste result from shives generated during groundwood production and from screening and handling forest product residuals prior to pulping. Additional solid waste is generated in the form of trim and nonsalable broke from manufacturing specialty products (glassine, parchment, solvent coated papers, etc.).

The industry's solid waste management practices have developed over the years with few specific plans or development efforts. Storage generally consists of bulk containers or on the ground piles for major sources with small containers of various configuration being used for minor sources. The primary concern is providing sufficient size storage containers between collection pickups. Very few storage problems occur because of the simple systems used. Very little labor is utilized to perform solid waste storage related duties.

Collection is generally provided by a combination of dump trucks and container hauling vehicles. Compactor trucks are seldom used except in small paper mills with limited solid waste quantities.

Processing is limited to specific applications of size reduction equipment to prepare combustible materials for burning and to limited use of stationary compactors for bulky wastes (often specialty papers or finishing areas and miscellaneous sources).

Disposal consists primarily of land disposal sites on property adjacent to the mills. Minimal planning and design of these sites have led to the industry's most pressing solid waste problems. Upgrading of disposal sites will require considerable effort over the next decade. Also, the increasing quantities of wastewater treatment sludge requiring disposal will rapidly utilize available disposal site space.

Resource recovery activities have received the bulk of the industry's solid waste management attention. Major energy recovery from bark wastes plus broke recovery and sale of salvageable materials provide significant economic returns to the industry.

Total solid waste quantities have been steadily on the increase since 1958 even though weight per unit weight of production has decreased. Similar patterns are projected through 1980 (Figures 1 thru 7). Solid waste to disposal has increased from the range of 9.8 to 10.2 million metric tons (10.8 to 11.3 million tons) in 1958 to the range of 14.3 to 16.2 million metric tons (15.8 to 17.8 million tons) in 1971. Quantities for 1980 are expected to reach the range of 18.6 to 22.5 million metric tons (20.6 to 24.8 million tons).

The cost of managing these solid waste quantities ($61.0 to $68.8 million in 1971) represents a significant expense to the pulp and paper industry. The main portion of this cost results from external collection operations with internal collection and disposal representing lesser portions (Figure 8).

Resource recovery activities undertaken by the industry contribute substantial solid waste management savings. Energy production from bark provided a 1971 savings between $46.9 and $56.4 million. Secondary materials sales were estimated to provide an additional income of nearly $5 million. Routine process operations that can be considered as partially resource recovery operations (chemical and broke recovery) are essential to the industry's economic structure.

Future solid waste generation and management activities will be influenced by existing and proposed environmental legislation. Increasingly stringent liquid effluent discharge limits will produce more wastewater treatment plant sludge (both primary and secondary). Additionally, increased attention to site requirements for lagoons and landfill sites will make sludge dewatering and combustion for energy value more prevalent. Emphasis on energy shortages plus increased disposal costs will encourage the industry to investigate the combustion possibilities for all combustible solid waste sources. Increased air pollution control solid waste may result from power generation equipment, but material recovered from the chemical recovery area generally can be returned to recovery process streams. Potential major solid waste quantities could result from flue gas desulfurization if required to meet air quality standards. However, this technology is still in the infant stages and only long term implementation could be envisioned for the pulp and paper industry. Another potential long term solid waste quantity increase could result from effluent color removal requirements. However, it is expected that systems employing chemical recovery or regeneration with combustion of the removed contaminants will keep this solid waste source small.

FIGURE 1

SOLID WASTE QUANTITIES - 1958*

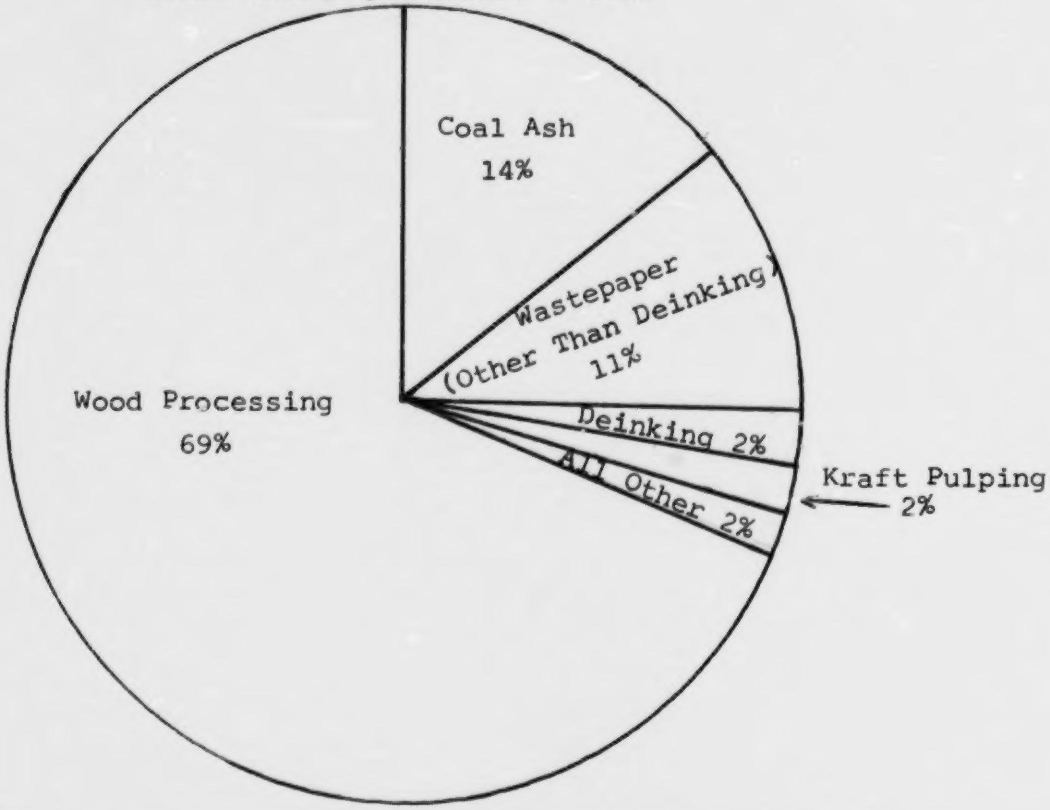
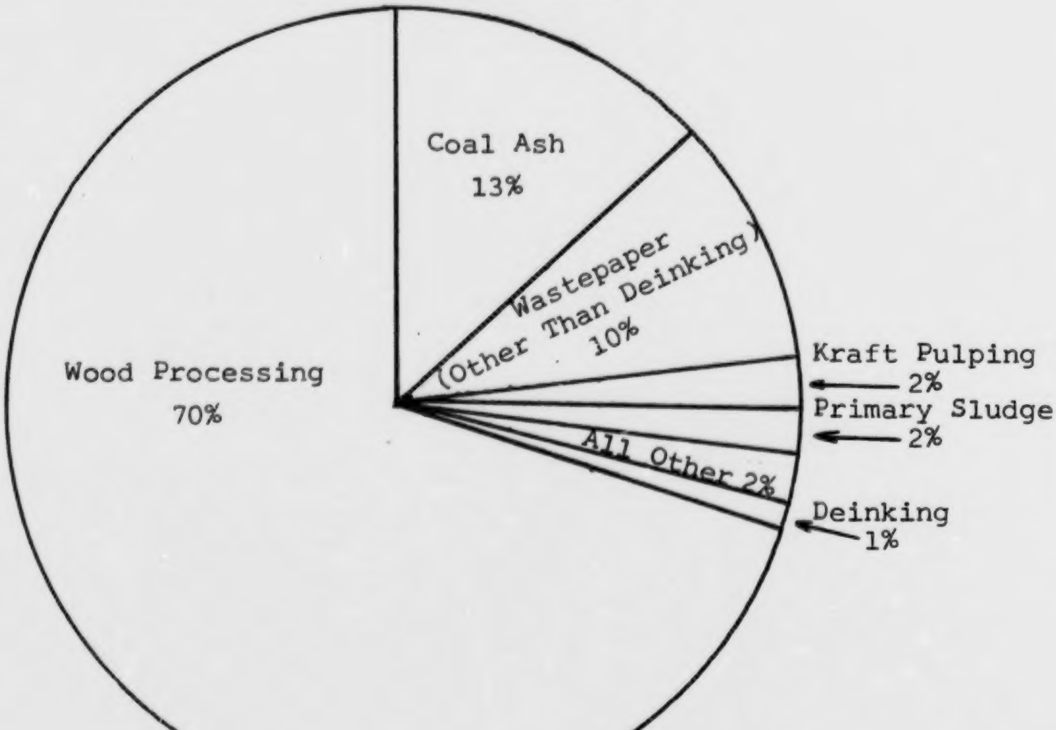


FIGURE 2

SOLID WASTE QUANTITIES - 1963*



*From Gorham International Inc.

FIGURE 3

SOLID WASTE QUANTITIES - 1967*

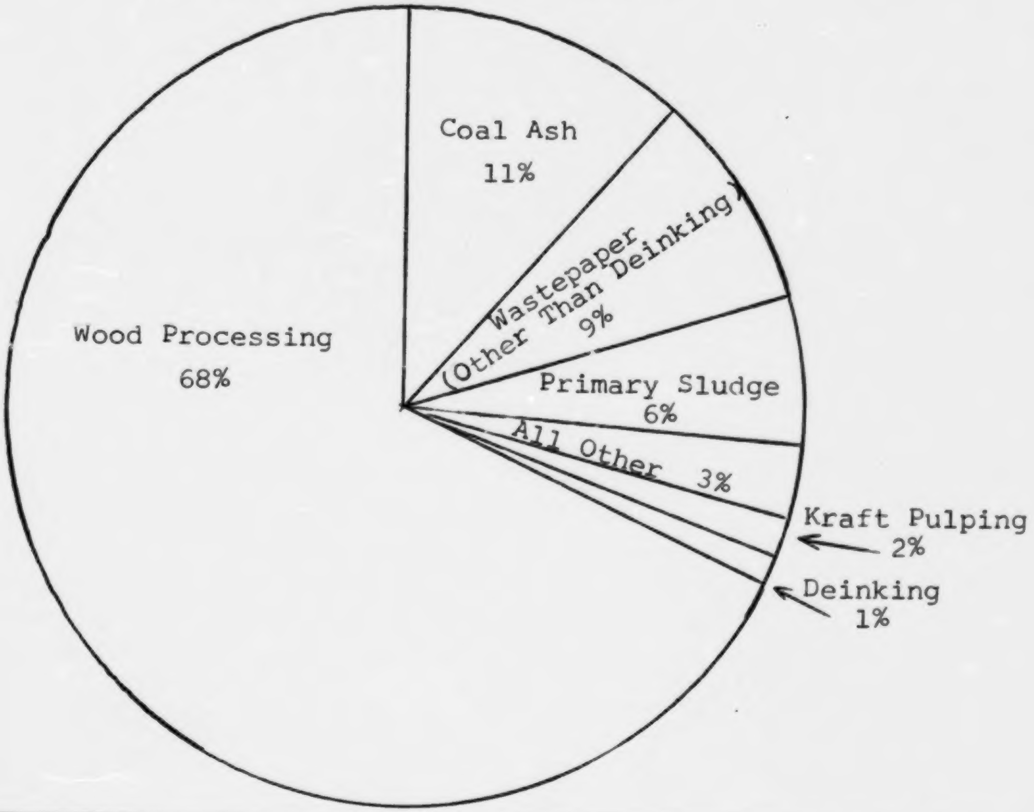
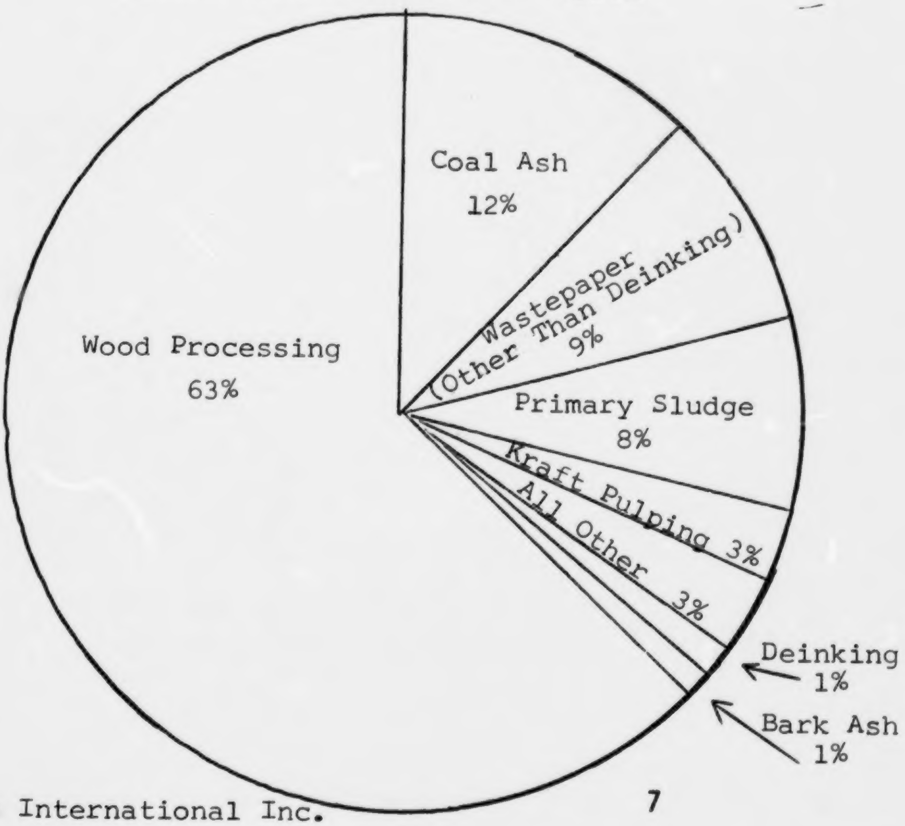


FIGURE 4

SOLID WASTE QUANTITIES - 1971*



*From Gorham International Inc.

TABLE 5
SOLID WASTE QUANTITIES - 1975*

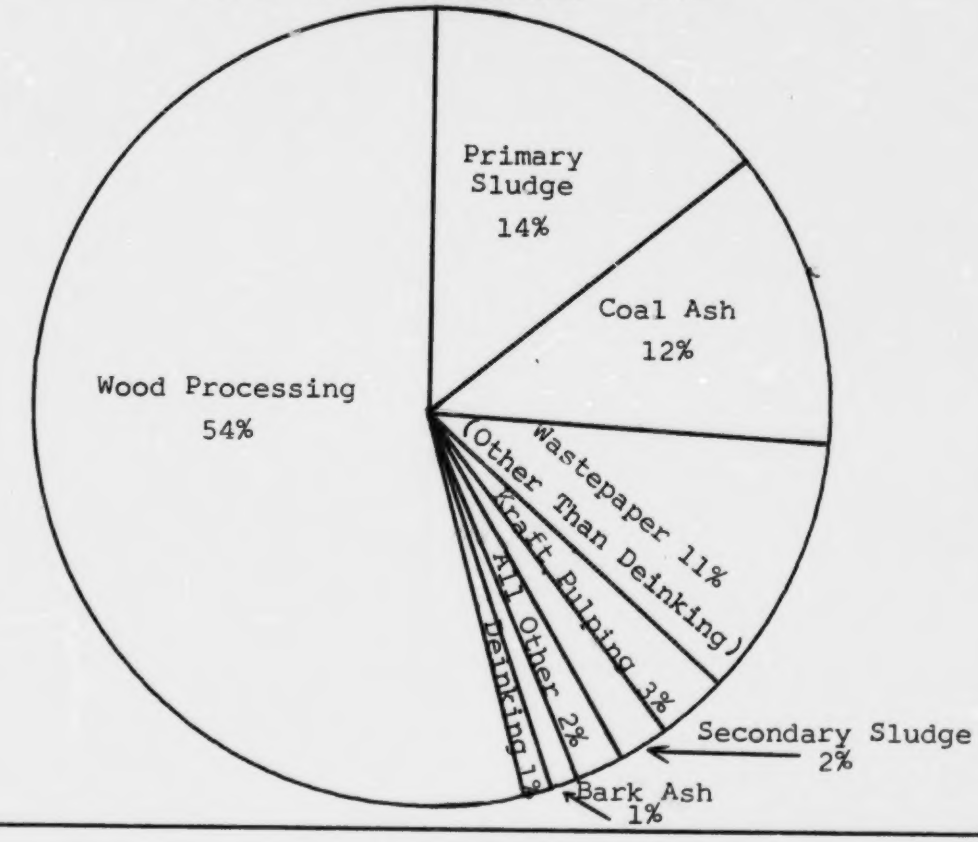
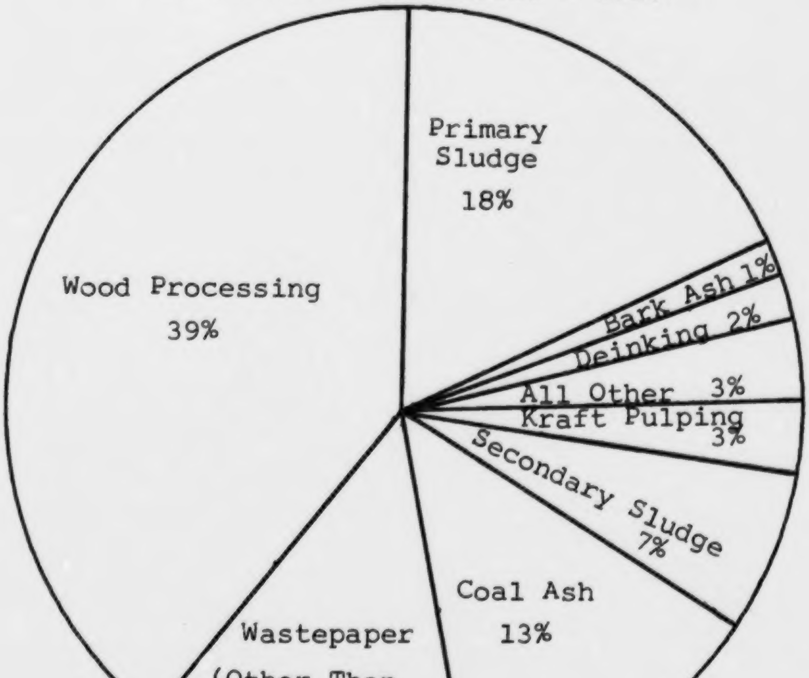


FIGURE 6
SOLID WASTE QUANTITIES - 1980*

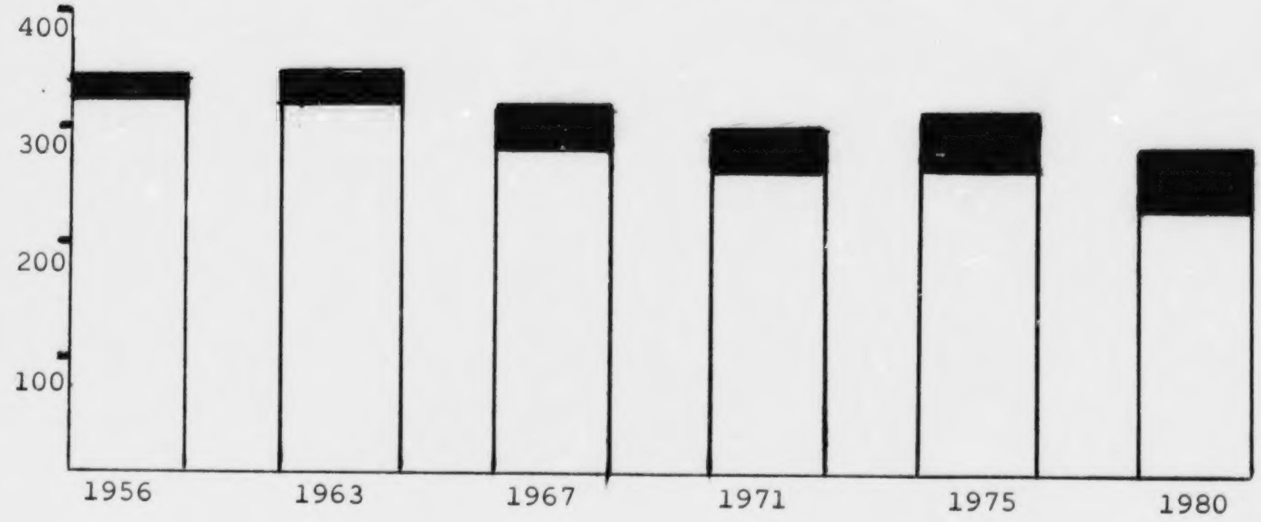


*From Gorham International Inc.

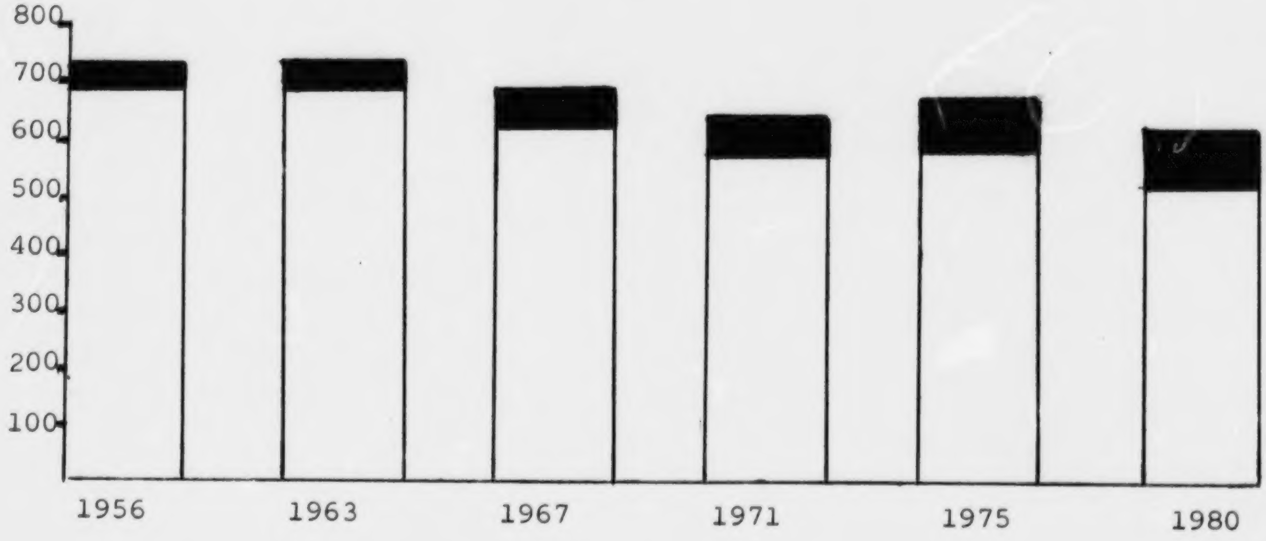
FIGURE 7

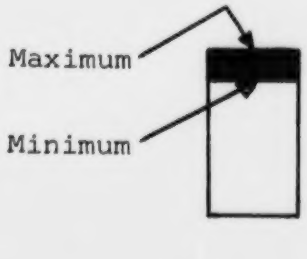
SOLID WASTE QUANTITIES TO DISPOSAL - 1971*

Kg/Metric Ton Of Production



Lb/Ton Of Production

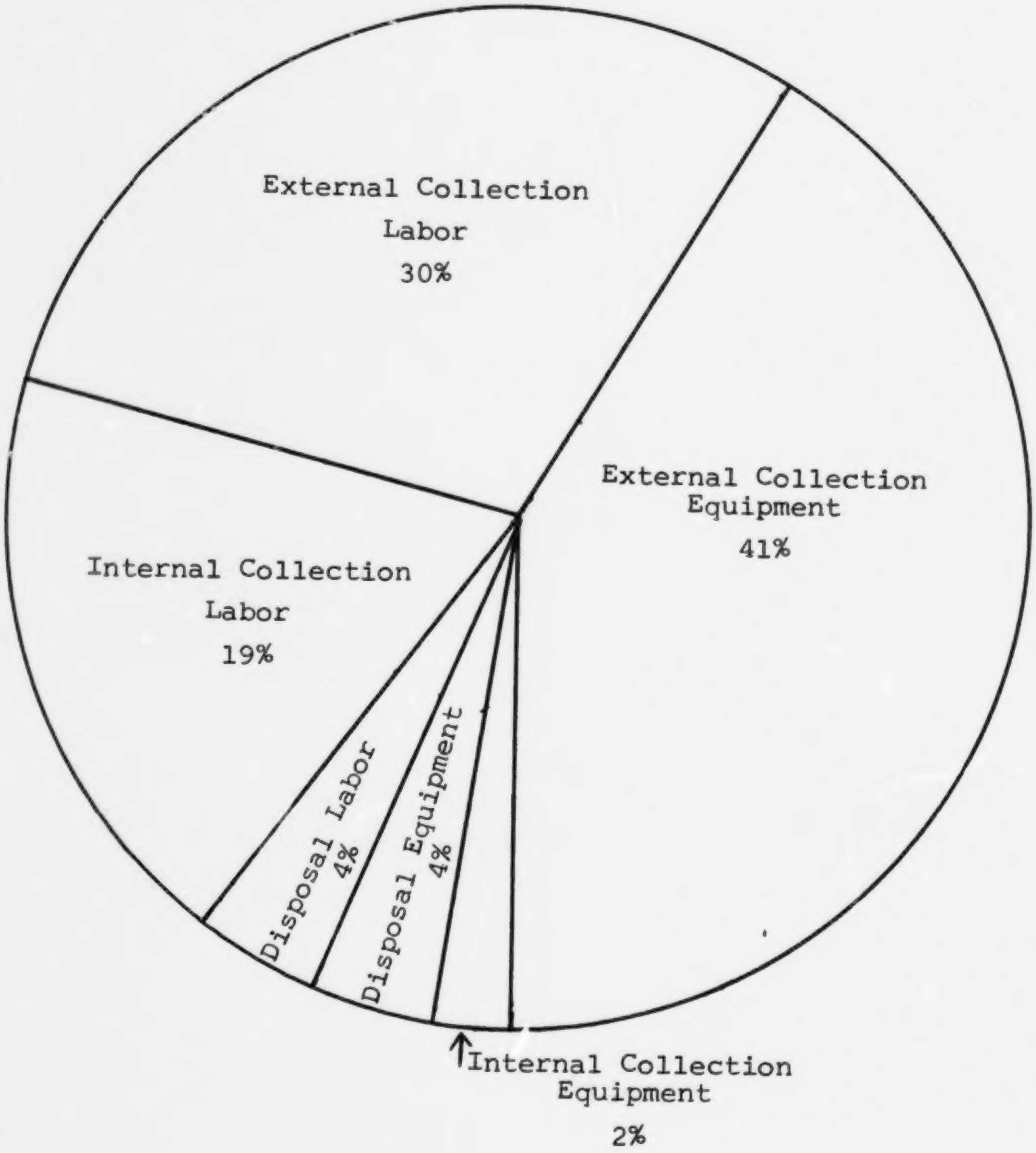



Maximum
Minimum

*From Gorham International Inc.

FIGURE 8

SOLID WASTE COST DISTRIBUTION - 1971*



*From Gorham International Inc.

The principal operational changes caused by legislation or regulations will be improved disposal site operation. State permit programs plus local ordinances will require mills to meet sanitary landfill criteria thus increasing disposal costs significantly. While the industry spent from \$4.7 to \$5.3 million to dispose of from 14.3 to 16.2 million metric tons (15.8 to 17.8 million tons) of solid waste in 1971, the 1980 cost to dispose of 18.6 to 22.5 million metric tons (20.6 to 24.8 million tons) is estimated to be between \$30.8 and \$37.1 million .

Basically, environmental legislation and regulations will increase some waste quantities and increase associated disposal costs. Thus, there will be greater economic incentive to increase raw material utilization, to increase resource recovery activities, and to make solid waste management operations more efficient.

To minimize the economic impact of increased solid waste quantities and disposal costs, individual mills can make more efficient use of labor and equipment while increasing resource recovery activities. Combustion of a greater percentage of bark is expected to actually reduce the total bark transported to disposal by 1980. Smaller reductions can also be achieved by making provisions to recover the energy value from other combustible solid waste. Primary wastewater treatment sludge also represents resource recovery potential for low grade paperboard products, structural products, agricultural products, and other secondary products.

For collection operations, the use of large versatile container hauling vehicles with different type containers for different waste sources can increase equipment and labor utilization. Combined with better planning and collection scheduling, internal changes can help offset the increased operating costs of state approved disposal operations.

To successfully meet the challenge of rising solid waste quantities and costs, the pulp and paper industry will investigate process alterations, resource recovery technology, and improved management approaches. While no single answer will satisfy all situations, technology tailored to specific mills' needs will provide improved solid waste management practices through the next decade.

CHAPTER III

PULP AND PAPER INDUSTRY STRUCTURE

The pulp and paper industry is believed to have started when the Chinese discovered the art of papermaking about 100 A.D. Prior to that time, parchment from animal skins and papyrus served as medium for written works. The first machine made paper in America was established in 1690(1). From that time to the present, the U. S. pulp and paper industry has spread from the Northeast to all sections of the nation possessing sufficient fiber resources. Additionally some nonintegrated paper mills and wastepaper mills have located near urban areas to be close to areas with high demand levels and wastepaper supplies.

Paper has been used in increasing quantities in the United States. Annual per capita consumption has risen from 161 kilograms (354 lb) per capita in 1958 to 242 kilograms (534 lbs) per capita in 1971. Everyday uses include sanitary products, communications, structural products, packaging, plus many others. The use of paper in various applications has become so common that people think more about the end use than the fact they are using a paper product. This chapter will briefly describe the characteristics and structure of the United States paper industry. If additional detail is sought, the reader may consult any of the pulp and paper technology publications listed in the report bibliography.

Product Categories

Paper is a general term used to describe a variety of fibrous matted or felted sheets formed on a screen from an aqueous suspension. "Paper" is one of three general subdivisions and is used in a specific sense to distinguish itself from the other subdivisions as the lighter, thinner, and more flexible products. The second general subdivision is paperboard and the third subdivision is designated as construction paper. Paperboard is heavier and less flexible. Construction paper, made of both paper and paperboard, is used in making construction products such as roofing felts.

Qualities characterizing paper are its weight and thickness, strength, optical properties, and the type of raw materials from which it is made (mechanical or chemical pulp).

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[1], v.2, p.298.

Pulps Used for Papermaking. Groundwood pulp is used for newsprint and printing papers. It is the lowest quality raw stock and is produced by mechanical grinding to separate wood fibers from resinous residues. Groundwood pulp is produced by forcing logs (normally 4 feet long) against a power driven abrasive stone to separate fibers. Refiner groundwood pulp is produced by passing wood chips through moving plates in equipment known as refiners.

Sulfite or acid pulp is used commercially for most printing papers and in tissue grades. Chemical cooking methods using sulfurous acid and a salt base are utilized to produce this pulp. Sulfate or kraft pulp, the most important pulp product, is used mainly in paperboard and coarse paper grades. Unbleached kraft is used in packaging while bleached grades are used in packaging boards and also in a number of paper grades such as printing grades and tissue products. Sulfate pulp is chemically produced by using a basic solution of caustic soda and sodium sulfide. It is the most economical chemical pulp while also producing the strongest fibers. Pine and Douglas fir as well as a wide variety of other trees with a high resin content may be utilized with both the type of wood and degree of cooking affecting the yield (40 to 60 percent by weight). Semichemical pulp is used principally in corrugating medium for paperboard boxes. It is produced by a mild chemical treatment on wood chips followed by a mechanical separation of the fibers. Though not as strong as kraft pulp, semichemical pulp gives a relatively high yield (70 to 80%)(2).

Wastepaper is principally used in the making of paperboard. The fibers are separated from the original product by mechanical agitation in a water slurry. Deinking may also take place, particularly for higher grade wastepaper products. In recent years, the use of deinked newsprint to produce additional newsprint has been increasing(3). Rag pulp and bagasse (sugar cane stock) constitute a small portion of raw materials for products such as high quality writing papers, types of paperboard, and wrapping paper.

The actual production of pulp and paper requires extensive manufacturing facilities and employs large amounts of labor and equipment to achieve the end result seen by consumers. This basic technology will be described in the next section.

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[2], v.2, p.334.

Production Processes

The actual operations encountered in the conversion of fibrous raw materials (primarily wood) to paper vary from mill to mill, but basic processes discussed below account for the most significant portions of output.

To prevent deterioration and maintain constant moisture content, logs are often stored under water or piled and sprayed intermittently. The latter practice has become more common than the former because of its lower cost. Also, increasing use of lumber industry residuals has led to more wood storage in chip form. Wood stored in roundwood form normally undergoes debarking prior to chipping.

In both wet and dry debarking processes the logs are frequently washed before debarking by a water shower to remove silt. In most cases the water discharge is activated by weight of the log itself on the conveyer. The suspended solids content of the effluent from the log washing is largely silt and is generally disposed of on the land along with grit from the pulp mill and ashes from the boiler plants. This effluent is increasingly being combined with the general mill discharge to the effluent treatment system.

Dry debarking methods are principally used in the United States, and wet debarking operations are declining. Dry debarking is accomplished using a slotted debarking drum equipped with internal staves which knock the bark from the log as the drum rotates. Ring debarkers are also used for dry debarking. In that process, one log at a time goes through the debarker which adjusts to the diameter of the log. Knifelike projections on the inside of the drum cut and remove the bark. The bark is then removed to bark boilers or to a solid waste disposal site.

Wet debarking is usually accomplished by one of three methods. The wet drum debarker is similar to the dry debarking drum mentioned previously. The basic difference is that the wet debarking drum rotates in a pool of water and the bark falls through the slots to be removed with the water overflow. Wet pocket barkers are stationary machines which remove bark from logs by rotating a confined wood stack against a chainbelt fitted with projections which raise the wood pile to allow bark to pass between the chains. Water is sprayed through holes in the side of the pocket to remove bark trapped in the wood stack or chainbelt. Hydraulic barkers use high pressure water jets to remove the bark from the logs as they move past the jets.

Once the bark is removed, the wood is normally chipped to provide small pieces required for pulping operations. Only conventional groundwood mills utilize wood in roundwood form for pulp production.

Pulping. Pulping can be broken down into two major methods, mechanical and chemical.

There are two methods used to produce groundwood pulps. The older of these is stone grinding, and is accomplished by grinding pulpwood on large grindstones. The other method, chip refining, converts pulpwood chips to groundwood pulp by using rotating disc or plate equipment known as refiners. Basically all groundwood pulp is produced from softwood raw materials.

Chemical pulping, the second major method, is accomplished using various chemical processes to dissolve undesirable constituents of the timber. In the kraft or sulfate process a water solution of sodium sulfide and sodium hydroxide is utilized to dissolve the lignin and pentosan fractions of wood while leaving the cellulose area less degraded. The cooking process occurs either in high temperature batches or in continuous digesters after which the pulp is separated from the cooking liquor. The waste liquor is fed to a kraft recovery system which provides for burning of the dissolved organic chemicals and recovery of the sodium sulfide and sodium hydroxide for recycle to the pulping process.

The sulfite process utilizes a cooking liquor containing sulfur dioxide, sulfurous acid, and bisulfite. Until the advent of the kraft process, sulfite pulping was the most important chemical pulping process. With pollution control legislation allowing limited effluent discharges, the sulfite pulping process has been modified to enable easier cooking chemical recovery and to minimize effluent discharges. Sulfite pulping processes are in use with bases including calcium, sodium, ammonium, and magnesium. Sulfite pulps are used in many final paper products including tissue and many printing and publishing grades.

There is a special sector of the sulfite industry known as the neutral sulfite semi-chemical (NSSC) process. Hardwood is converted into pulp for the manufacture of corrugating medium. A two stage process is used in which wood chips are softened in a cook with a neutral sodium or ammonium sulfite solution and then defibered in a refiner. This method brings a higher yield than conventional sulfite pulping (70 to 80 percent on a bone dry basis).

The pulping process followed by washing and screening produces a fiber slurry that can be used to manufacture paper and paperboard products.

Pulp Bleaching. For production of paper grades with high brightness, the pulp must undergo bleaching to remove color components present in the raw material.

Chlorine is the principle agent involved in pulp bleaching. The use of chlorine is followed by extraction of the solubilized materials in sodium hydroxide solutions. The chlorination and extraction steps are followed by a series of steps containing treatment with chlorine dioxide or sodium hypochlorite with additional extraction steps as required.

Bleaching steps are usually conducted at near atmospheric pressure in large stirred containers. There must be washing operations between adjacent bleaching steps to separate the pulp from the spent bleaching chemicals. In cases of pulp bleaching, there is a development of substantial quantities of waste water for which no inexpensive disposal or recovery system is now available. At the present time, much activity is focused on bleaching with oxygen and developing a closed chlorine bleaching system to reduce liquid effluent treatment costs.

Papermaking. The papermaking process consists of dewatering a dilute aqueous slurry of pulp fiber through a continuous screen moving at high speeds.

Fourdrinier paper machines are utilized in making most paper and board. The pulp slurry is poured on top of a continuous filtering screen (the wire). Water drains through the screen, leaving the paper on the top. The sheet is removed from the screen and passed through wet presses and a series of drum dryers to evaporate the water remaining after the draining process and wet pressing. Fourdrinier machines produce products from lightweight materials to relatively heavy board.

A cylinder machine forms the paper on a rigid cylindrical screen immersed in a stock bath as opposed to the travelling flexible screen of the fourdrinier. Cylinder machines are used primarily in the production of high caliper board that involve multi-ply lamination from several cylinders. After drying, the paper is removed from the machine and formed into large rolls to be rewound and slit into smaller rolls, sold directly to the consumer, or to be converted to other end products.

The paper and paperboard produced from the industry's mills is marketed in a definite structure based upon various product groupings and geographical production characteristics.

Paper Products

The breakdown of the industry production is into three major divisions; paper products, paperboard products, and construction paper and paperboard products. The three major classifications are again broken down into subcategories, including: newsprint; coated printing, writing, and fine papers; unbleached industrial and converting papers; bleached industrial and converting papers; tissue papers; containerboard; bleached board; bogus board; construction paper; insulating board; hardboard; and saturating felt.

Essentially all the kraft linerboard is produced in the South and Pacific Northwest. This is also true of unbleached kraft paper and bag paper. The Southern area produces most sack kraft paper. A large percentage of coated and fine paper is produced in the paper mills of the Northeast and Midwest as is much of the tissue paper. Bogus and building paper are produced mostly in or near urban centers where the principal raw material, waste fiber, is more readily available.

The older mills of the Northeast and Midwest have become producers of low volume specialty products commanding higher prices and levels of customer service. The large southern mills focus on low price commodity products because of the necessity to limit their products and thereby achieve maximum manufacturing efficiency.

The large manufacturers such as the southern kraft and linerboard mills are the most capital intensive sector of the industry. The small fine paper, tissue, and boxboard mills of the Northeast and Midwest are usually independent companies with relatively low production volumes.

Industry Production

The pulp and paper industry has experienced reasonable growth over the last fifteen years (Table 1). Their growth has maintained this industry as one of the largest in the United States. Variations between pulp and paper production result from the interaction of several variables. The most important contributing factors are use of recycled fiber, imported pulp, exported paper, and the addition of coatings during papermaking.

TABLE 1

INDUSTRY PRODUCTION*

Production	1958	1963	1967	1971
Pulp (Metric Tons)	19,769,000	26,701,000	33,266,000	39,847,000
Pulp (Tons)	21,796,000	29,939,000	36,677,000	43,933,000
Paper and Paperboard (Metric Tons)	27,956,000	35,582,000	42,582,000	49,968,000
Paper and Paperboard (Tons)	30,823,000	39,230,000	46,926,000	55,092,000

*From United States Department of Commerce Data

While increased environmental awareness has contributed to growing waste quantities, production growth has also increased waste volumes requiring management. The development of solid waste problems and industry solutions compiled with an evaluation of future trends and technology are the major concern of this report and will be covered in detail by subsequent chapters.

The total production data based on United States Department of Commerce census years plus 1971 data will be used as data base numbers throughout this report. Thus, all solid waste generation quantities and rates will be related to these standard production numbers.

CHAPTER IV

SOLID WASTE GENERATION POINTS AND CHARACTERISTICS

The pulp and paper industry's solid waste generation is characterized by several major sources common to all types of mills, plus individual sources confined to specific industry segments. The common sources include wood processing, power generation, wastewater treatment, manufacturing services, and personnel activity. Major individual solid waste sources include wastepaper reclamation, chemical pulping, and specialty products manufacturing. The generation points and general solid waste characteristics will be presented. This background information is important when considering management and technological alternatives.

Wood Processing

The largest single solid waste source is the incoming wood supply. Bark is removed from the incoming wood during handling and storage and is accumulated as general wood yard refuse. The remaining bark and a portion of the wood is removed during debarking operations that are used to prepare the wood for either chemical or mechanical pulping. An additional amount of bark and grit is deposited in the log flume water where flumes are used for wood transportation.

Bark is a highly complex heterogeneous material from a chemical viewpoint. It has a thin, active inner layer and a relatively inert outer layer. Different species exhibit various layer thicknesses and appearances. Analytical data on bark samples exhibits wide variations in detailed composition even within a single species depending on age, growth location, and sample size.

Native bark tissue contains a maximum of only about one percent inorganic material (equivalent to wood). However, normal bark samples contain up to twenty percent ash that results from windborne particles and logging methods(4).

A large number of organic compounds can be extracted from bark by a variety of solvents. Terpenes, fats, waxes, resins, tannins, sugars, starch, gums, pectins, and many other organic constituents make bark a solid waste requiring careful disposal attention. Leaching of water soluble components plus anaerobic degradation can lead to color, COD, BOD, bacterial, and dissolved oxygen changes in ground and surface waters(5).

Bark's properties and generation rates also make it an excellent candidate for resource recovery activities that will be discussed later in this report.

Power Generation

Power generation in the pulp and paper industry represents a significant solid waste generation point in areas that utilize large quantities of coal and bark for fuel. The noncombustible ash may be collected as bottom ash, clinkers, or fly ash depending on furnace design, air pollution control devices, fuel preparation, and operating conditions. With continually increasing use of air pollution control devices, the proportion of fly ash collected continues to increase.

Coal ash has ten major constituents that are tested for by the United States Bureau of Mines. These ten chemical compounds are SiO_2, Al_2O_3, Fe_2O_3, TiO_2, P_2O_5, CaO, MgO, Na_2O, K_2O, and SO_3. The average analysis for the three main constituents (SiO_2, Al_2O_3, and Fe_2O_3) are approximately 46, 26, and 18 percent respectively, thus making up about 90 percent of ash from bituminous coal(6).

While the above major constituents are present as oxides, they actually occur in the ash as a mixture of silicates, oxides, and sulfates with small quantities of phosphates and other compounds.

The physical characteristics of coal ash generated as clinker and bottom ash will vary in size and shape depending on actual furnace design and operation. Flyash consists of finely divided spheroids of siliceous glass with diameters from one to fifty microns. Carbon is found in flyash in the form of irregularly shaped coke particles. Under optimum operating conditions, the carbon content will be negligible (less than one percent); however, some samples have possessed up to twenty percent(7).

Bark ash yields a somewhat different chemical analysis than does coal ash. To determine chemical makeup bark ash samples have been tested for the same ten constituents as coal ash plus $CaCO_3$ and MnO. The calcium oxide content is the largest single component averaging at least fifty percent. Silicone dioxide is the next largest component (3 to 25 percent) while unlike coal, very little Al_2O_3 or Fe_2O_3 are present(1).

Ash from coal and bark ash is normally free of any biological activity, but as seen from the diverse chemical structure, it is subject to further chemical activity. The primary consideration in managing power generation ash is the potential leaching of the chemical constituents that could lead to ground or surface water contamination.

Personnel Activity

Additional solid waste is generated by the manufacturing and support personnel employed within the pulp and paper industry. This generation appears to be quite constant from mill to mill and includes lunch wrappings, newspapers, cafeteria wastes (if applicable), office wastepaper, etc.

This solid waste contains components similar to municipal solid waste. The combustible portion (primarily paper) normally exceeds fifty percent. Putrescible wastes from lunchrooms and cafeterias (food wastes) present most difficult to manage solid waste for this source because they can create nuisance conditions and attract pests if not properly handled.

Manufacturing Services

Various service functions required to support pulp and paper industry manufacturing operations also generate solid waste. The major solid waste producing services include shipping, receiving, shops, rail car cleaning, and warehouse activities. This solid waste source will vary significantly from mill to mill and from

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[1], v.2, p.410.

time to time. Mills shipping products in roll form will generate less shipping room solid waste than a mill shipping products in reams or sheet form. Solid waste from the other mill services will vary depending on mill type and internal practices.

The following examples indicate the solid waste types for common manufacturing services:

Shipping: packaging scraps, wrapping

Receiving: corrugated boxes, packing material

Garage: broken parts, packaging materials

Shops: wood scraps, replaced parts

Rail car cleaning: paper, steel strapping, wood scraps

As seen above, manufacturing services solid waste contains a high percentage of paper and wood with other components being generally slow to degrade (metal, plastic, styrofoam, etc.). Potential contaminants could result from specific sources (such as oil and grease from garage wastes), but generally special provisions are made for difficult to handle materials.

Wastewater Treatment

Solid waste generation from wastewater treatment represents a significant source and one of a complex nature. The general category includes solid or semi-solid residuals resulting from either primary or secondary wastewater treatment operations. However, the actual form of the sludge will vary extensively and, coupled with local conditions, will result in a variety of optimum disposal techniques.

Sludge from primary wastewater treatment consists of settlable materials present in the mill wastewater including lost fiber. Actual components will vary depending on the manufacturing processes and practices used in the mill.

Normal sludge analyses determine the ash content as an indicator of reuse possibilities and disposal alternatives. High percentages of ash generally result from mills utilizing extensive coating facilities and from wastepaper mills (particularly deinking mills). Losses of clay, TiO_2, and other coating or filler materials often result in ash values in the area of 25 percent(8). Ink, fillers, and other contaminants removed from wastepaper can produce sludges having an ash content of fifty percent(9). Routine materials that occur as ash in the sludge include sand and grit entering the wastewater treatment system from wood yard washing areas, pulp cleaning, and general mill floor drains and housekeeping activities.

The combustible portion of primary sludge consists of mainly organic compounds from the incoming wood. Lost fiber plus various other organic components from the wood possess significant BOD and can create water contamination if not properly managed during disposal operations. Physically, primary sludge is normally removed from the clarifier in slurry form at only a few percent consistency. Depending on the dewatering techniques used, the final solids content will be up to 35 percent. At the higher solids contents, primary sludge appears like a solid material and will hold a general shape even though it is not stable when subjected to pressure.

Secondary wastewater treatment sludge consists primarily of biological solids. It has essentially no fiber content and is generally of a gelatinous nature. It is removed from secondary clarification units as a low consistency slurry (generally lower consistency than primary sludge).

Sludge from domestic sewage generated within paper mills may be intermixed with primary and secondary sludges if process and sanitary wastewaters receive joint treatment. However, this practice either has been or is being eliminated in most mills to prevent fecal contamination of the large volume process water effluent by a small quantity of sanitary effluent. In joint systems little difference can be detected in sludge characteristics. The principal change is the possible presence of fecal organisms (possible pathogenic organisms) that complicate disposal from a public health viewpoint.

With the common practice of either septic tank or joint municipal treatment for sanitary wastewaters, the associated solid waste generation is removed from the industry's internal solid waste handling systems.

Sludges from water treatment plants contribute to additional solid waste generation when introduced into the wastewater treatment plant. The primary contributions to the normal sludge are additional grit and settlable matter from the fresh water supply and some iron and aluminum salts resulting from the water purification chemicals. Normally, only small quantities of organic material are present in the water treatment sludge, thus having little effect on secondary wastewater treatment sludge generation or characteristics.

Wastepaper Reclamation

One industry segment that has a unique solid waste generation factor is the wastepaper reclamation sector. Contaminants present in the wastepaper must be removed before new paper and paperboard products can be manufactured from the available fiber. These contaminants include wire, strapping, tramp metal, glass, plastics, dirt, and other foreign substances plus coatings, ink, fillers, etc. that were included as part of the paper product when manufactured for its original use. The degree of contamination and the amount of cleaning required will vary with each batch of wastepaper and with the specific end use.

This solid waste is a heterogeneous material consisting of the kind of items mentioned above. Depending on the actual process stage during which it is removed, the physical appearance will differ. Some material, particularly rag, string, wire, tape, and other stringy-type material is removed in a continuous rope with all the materials intertwined. Much of the other material that will break into small pieces, such as glass, plastic, and heavy, dense contaminants, will be removed as a mixture of these small pieces.

Mills using mixed wastepaper to produce lower grade products will generate more solid waste than mills using high grade segregated wastepaper. However, the general type of contaminants will remain similar. For example, mills using waste newspaper will find fewer large pieces of scrap metal and nylon tape than a waste corrugated user. But the diversity of foreign objects found in the wastepaper supply will be similar. The primary distinction in generation rates is made between mills operating deinking mills and all other types of operation.

Chemically, most of the wastepaper reclamation solid waste is stable and will not present contamination problems. However, depending on the wastepaper source, it is possible for nearly anything to enter the wastepaper stream. Consequently, this generation point can yield a great variety of contaminants and requires that solid waste characteristics be carefully observed to prevent any unnecessary contamination or personnel injury.

Chemical Pulping

During chemical pulping to produce cellulose fiber suitable for various papermaking processes, nearly all the solid material removed is in a dissolved state with the majority entering the chemical recovery processes and the remaining portions entering wastewater treatment systems. For the portion entering wastewater treatment systems, any solid waste generated is covered by the discussion of wastewater treatment sludge.

Concerning chemical recovery in the kraft pulping industry, some material does exit from the process as solid waste. The two principal sources are rejects from slakers and unburned lime rejects from the lime kilns. Also, some mills dewater dregs from the green liquor clarifier and discharge these as solid waste.

The solid waste removed at the slakers appears to be little lumps or pebbles. The actual components will depend on the slaking operation's efficiency. The waste will be a mixture of inert particles in the chemical recovery system and calcium carbonate. The material from the lime kiln consists of inert contaminants in the lime and a small amount of unburned lime that will vary with kiln operation.

The dregs from the green liquor clarifier consist of inert materials such as iron compounds, carbon, grit, and refractory material. Depending on the completeness of the dregs washing operation, some sodium salts will be removed with the dregs(10).

In sulfite pulping chemical recovery systems, inert materials plus some oxide of the base cooking chemical will be removed in a solid form. The actual generation point will vary with mill design but is commonly at the ash washer or the cooking liquor filter(10).

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[10], p.3-17a.

[10], p.3-65a.

Removal of inert contaminants from the cooking liquor is the objective of the chemical recovery washing and cleaning systems. However, some of the active chemicals are normally removed with the inert fractions indicating the need for caution in disposing of these solid waste materials.

Specialty Products

Specialty product manufacturing requires the addition of nonpulpable, noncellulosic materials that lead to the generation of solid waste materials that cannot be reused in the same fashion as most trim and processing broke. Products such as glassine, zinc oxide coated papers, solvent coated papers, high wet-strength grades, plastic coated papers, and certain types of industrial packaging materials are the major examples of this solid waste category.

These solid wastes are normally combustible and the chemicals added during manufacture are in a stable condition. Physically, the material consists of scraps and pieces of the final product that are too small or contaminated for sale. All specialty products solid waste is generated in paper mills and is not mixed with wastes from pulp mill areas. They are normally generated at one process location making them easy to manage as a separate source.

Groundwood Production

Mechanical pulp production represents another individual process solid waste source. In the grinders, small pieces of wood called shives will not grind properly and must be removed from the grinding pocket for disposal.

The material consists of small wood fragments with no external contaminants added. Again, this source is generated at a central process point making collection simple.

Residuals Handling Loss

Another small solid waste source results from the handling of residuals (chips, sawdust, and shavings) used for wood pulp production. Losses occur during chip screening, conveying, and feeding to the digester.

This source consists of wood material that is not of the proper size for the intended use. Also, magnets are often placed in chip or sawdust lines to remove nails, wire, and other ferrous material that is present in the wood. These sources generate small amounts of material that do not present any significant problems.

Summary

The various solid waste generation points, waste types, and general characteristics have been presented in this chapter. This discussion indicates that different potential problems exist for different generation points. From a waste characterization viewpoint, solid waste from the wood processing, wastewater treatment, power generation, and chemical pulping generation points present the most potential disposal problems if not properly managed.

Subsequent presentations of existing solid waste practices and total quantities will more clearly define the major solid waste problems deserving industry attention.

CHAPTER V

SOLID WASTE MANAGEMENT PRACTICES

The solid waste management practices presently utilized in the pulp and paper industry have not changed drastically over the past years. The use of large specialized solid waste collection vehicles (container-hauling vehicles and compaction equipment) plus increasing use of incineration and energy recovery have been the most prominent changes of the recent past. With the large solid waste quantities generated from essentially point sources, the storage and collection practices tend toward bulk material handling methods rather than toward methods commonly used for residential solid waste systems. With regard to specific solid waste sources, industry practices tend to be similar from mill to mill with minor differences dependent upon local conditions. Based on the previous chapter's discussion of solid waste generation points, emphasis will now focus on the industry practices used to manage the solid waste generated.

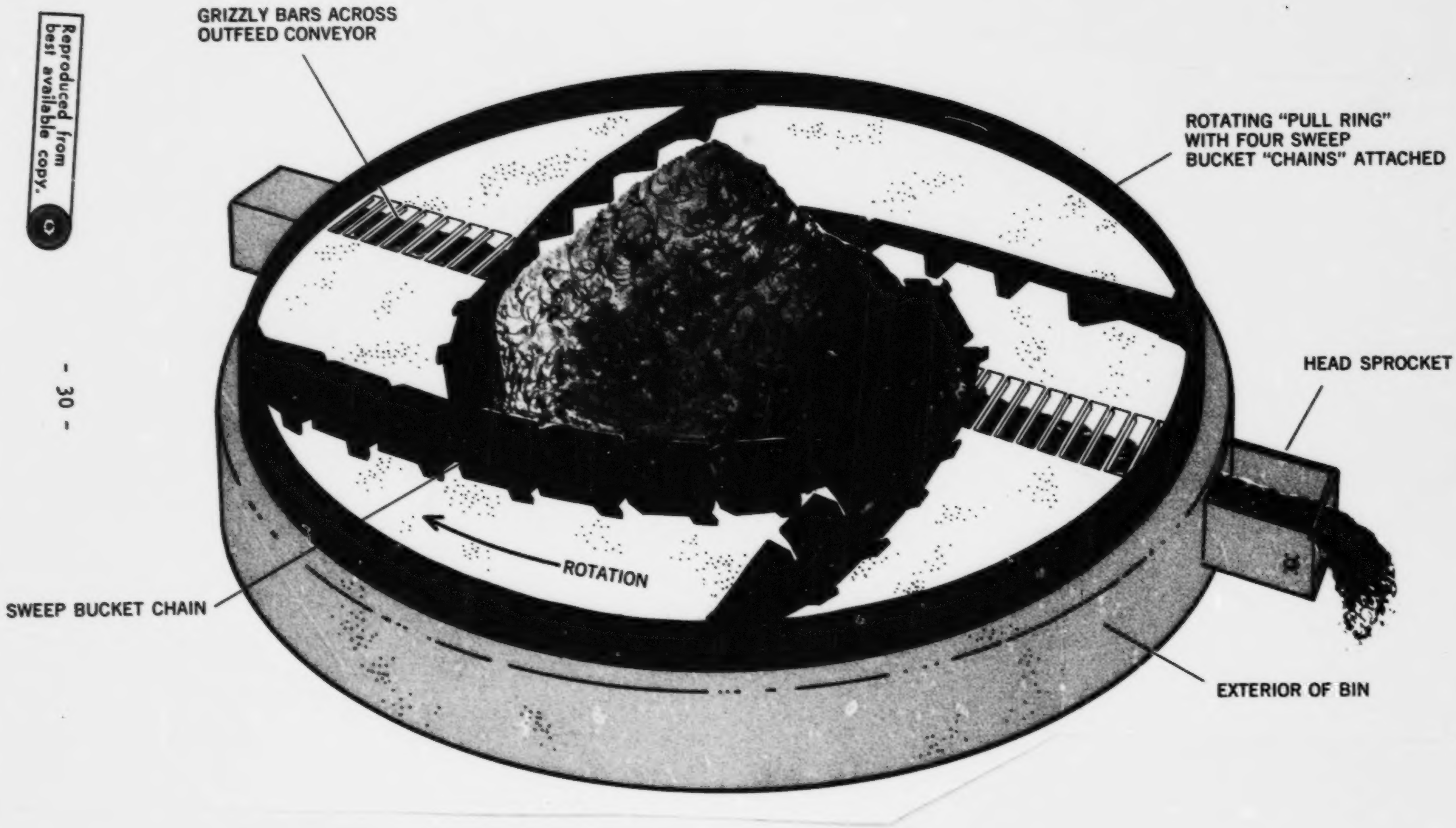
Storage

Solid waste materials must undergo storage until sufficient quantities have been generated to justify collection. Actual storage practices depend on the solid waste characteristics, the generation area, and the ultimate resource recovery or disposal methods to be employed.

Bark and related wood yard solid wastes are normally handled and stored by one of two methods, depending on their final use. The bark from debarking equipment that is going to be utilized for fuel value normally is placed in some type of enclosed storage bin unless it is conveyed directly to the boilers. Current practices are to provide a storage system that will even out the feed rate to the boilers and eliminate the surges associated with direct feed systems. The storage facilities that are currently most popular are the automatically unloading or feeding bins that continuously remove stored bark for conveyance to the boiler. A popular storage system illustrating this general design is produced by Atlas Systems Corporation (Figure 9). Other bark and wood yard solid waste normally collects at the generation point and accumulates until removed by front end loaders and dump trucks. In some instances, it may be bulldozed into piles to await collection but generally no storage equipment or facilities are provided.

FIGURE 9

"ATLAS" STORAGE AND FEED SYSTEM*


GRIZZLY BARS ACROSS OUTFEED CONVEYOR
ROTATING "PULL RING" WITH FOUR SWEEP BUCKET "CHAINS" ATTACHED
HEAD SPROCKET
ROTATION
SWEEP BUCKET CHAIN
EXTERIOR OF BIN

*From Atlas System Corporation

Reproduced from best available copy.

Ash from pulp and paper industry boilers is stored in several ways with the type of combustion unit and air pollution control devices being prime considerations in selecting proper storage methods. For ash collected as bottom ash in coal fired units, an ash hopper that can be easily discharged into a truck positioned under a gravity fed chute is the most common storage technique. This type of bottom ash collection is often combined with the air pollution control devices when mechanical dust collectors or other dry particulate collection methods are used. For boilers with wet scrubbers or other wet particulate collection equipment, the wet flyash is normally placed in a flyash pond, tank, or lagoon for settling and storage. This storage may be short term with periodic removal of settled material to a disposal site, or the storage lagoon may act as the final disposal site. Removal of settled ash is normally accomplished by using a clamshell bucket on a crane to load the dump trucks used for transportation. Another method commonly used is to employ a two section lagoon and alternately pump to each section. After one section has been allowed to settle, the water on top is pumped to the other lagoon and settled ash is removed with a front-end loader.

Boilers burning little or no coal may use removable containers to store ash resulting from small percentages of coal, oil, or bark used as furnace fuel. Depending on the boiler capacity of a mill, the fuel mix, required air pollution control equipment, and operating conditions, ash may range from an insignificant solid waste source to one of the major solid waste problems faced by the mill. Overall, dry ash is a homogeneous solid waste that is generally stored in bulk storage systems to facilitate truck loading and unloading with wet ash being placed in settling type storage areas, either for partial dewatering or for final disposal.

Industry practices for wastewater treatment solid waste (sludges) are quite diverse and difficult to determine based on available information. For purposes of this study, it was considered sufficient to estimate actual industry practices while noting the trends and predicting the future impact of such wastes on the industry's solid waste management systems.

Primary wastewater treatment sludge may be handled in several ways. As removed from primary clarification units it is essentially a liquid (1 - 5 percent solids) and can be pumped. Mills with sufficient land area normally prepare lagoon areas where this sludge can be placed to undergo additional natural dewatering. However, mills without available land, or that can not provide proper lagoon sites, are faced with seeking alternative solutions. These alternative solutions employ various processing steps that are discussed later in this chapter.

Sludge pumped from the clarifiers is not normally stored prior to dewatering unless it is placed in lagoons. Dewatered sludge is handled by conveyor and can be stored in outdoor piles to await collection if necessary.

Secondary wastewater treatment sludge is more difficult to dewater than primary treatment sludge, thus prompting storage in lagoons. Existing secondary wastewater treatment in the pulp and paper industry greatly favors either natural or aerated lagoons with no secondary clarification. Thus, solid material generated by secondary treatment undergoes natural sedimentation with some ultimate deposition in the treatment lagoons, while the remainder leaves the lagoon with the treated mill effluent. Mills with limited space that have installed activated sludge or modified activated sludge secondary treatment systems are faced with disposing of a difficult to dewater sludge material. Some mills simply lagoon this sludge while others have attained more successful dewatering by mixing the primary and secondary sludge together, thus using the fibrous primary sludge as a filter or dewatering aid. Secondary sludge dewatering is normally undertaken only when incineration is employed or when lagooning is impossible. The impact of both primary and secondary sludge on the industry's solid waste management systems will be discussed in more detail later in this report.

Solid waste resulting from wastepaper reclamation facilities is much different from that generated by any other operations. It contains a high percentage of metal and other foreign matter that enters the mill with the wastepaper. The material is actually removed at several points during the wastepaper reclamation process. Rags, wire, filament tape, and other long, stringy-type materials are often removed during the pulping process by what is called a ragger. Heavy materials and dense metals are often removed in the pulping unit by being collected in a junk box. Following the pulping of the wastepaper, cleaning equipment similar to that used in processing virgin wood pulp is utilized to remove contaminants. It also undergoes storage in a larger variety of storage containers than any other solid waste category. Many small wastepaper mills have developed storage systems unique to their individual requirements. Various sized wheeled carts, dollies, and other containers (that can be transported manually, by small in-mill vehicles, by overhead crane, or by conveyors) are utilized to store this industry sector's solid waste. Final storage containers are normally containers that must be handled by mechanical methods due to this solid waste material's high unit weight.

Solid waste materials generated in the chemical pulping and recovery areas are predominantly stored in an outside area where they can be conveniently picked up by a front end loader. While sometimes deposited into a removable container, this solid waste tends to corrode the common metal containers thus shortening their useful life. Because of this problem, most mills resort to on-the-ground storage with provisions for front end loader pickup.

The other solid waste sources (personnel, manufacturing services, specialty product manufacturing, etc.) represent only a small portion of the industry's solid waste, but do represent a large number of generation points. Thus they usually receive combined storage in containers placed to receive solid waste from several sources. Small containers (usually salvaged drums) may be used at the generation points with periodic transfer to larger, centrally located removable containers. Whether the mill operates its own collection system or hires a contractor, large containers (0.8 to 31 cubic meters; 1 to 40 cubic yards) are the common storage method.

Very little direct labor is associated with storage functions. Most of the effort required to place solid waste into storage facilities is part of the production workers' job where the solid waste is generated. For high volume solid wastes that are generated on a nearly continuous basis, transfer from generation point to storage facilities is generally automatic. The only significant labor input results from the emptying of solid waste drums, wastebaskets, etc. and transporting this solid waste to the outside storage containers.

Also, since very little putrescible solid waste is generated within the mills, very few problems concerning sanitary conditions exist. Only lunch room and cafeteria solid waste normally require precautions to prevent unsanitary conditions.

Storage is generally quite efficient with minimal solid waste scattered in mill production areas. Naturally some mills are better kept than others, but the emphasis on general housekeeping and prevention of unsafe clutter has increased substantially over the past few years.

Collection

Solid waste collection functions in the pulp and paper industry vary according to solid waste type and other local conditions. However, most mills employ some type of container collection system for general mill solid waste, with other special collection vehicles for specific solid waste sources.

The container collection systems used in the industry include nearly every type offered on the equipment market. Many mills use the haul away type container that is hydraulically hoisted to a secure position on the rear of the truck. Other mills with large solid waste volumes use the roll-on, roll-off containers. This system is also often used in conjunction with stationary compactors at points of high solid waste generation.

The use of containers that are emptied into compactor trucks (primarily over-the-cab) are used most often by private contractors who service small mills. This method is also more prevalent in nonintegrated mills not producing pulp. Pulp mill solid wastes tend to be wetter and of a more noncompactable nature than paper mill solid wastes, making the use of compaction collection equipment of limited value.

Noncompaction collection trucks are used extensively for wood yard refuse, chemical pulping and recovery solid waste, boiler ash, dewatered sludge, and miscellaneous noncompactable mill solid waste generated either continually or intermittently in large quantities. Large dump trucks (7.6 to 10 cubic meters; 10 to 13 cubic yards) are the predominant open collection vehicles. Also 3.8 cubic meter (5 cubic yard) dump trucks are used for minor source collection duties. These open trucks are normally loaded with front end loaders that are assigned to solid waste handling duties.

Collection labor is normally provided by the yard crew or service crew. Their responsibility begins when the solid waste is deposited in the proper storage container or area and generally carries through disposal. In some instances the special solid waste sources will be the responsibility of men assigned from the waste generating department. For example, the power plant or wastewater treatment plant may provide equipment and labor to transport ash and sludge to the mill disposal site.

The use of private collection companies is very limited among the large integrated pulp and paper mills that produce the major percentage of the industry's products. In these mills, contractor service is generally limited to specialized solid waste sources, particularly those containing putrescible waste, such as lunch room or cafeteria solid waste. Smaller nonintegrated paper mills do use contractor services to a significant degree. This practice is based primarily on these mills' more urban locations and lack of land for disposal sites. Also, the small paper mills do not have many of the large quantity generation points found in integrated mills, thus greatly altering the economics of internal systems versus contractor services.

Scheduling of collection pickups is generally a random system based on operator's experience and operating conditions. While collection scheduling is not as important as in normal residential collection, it would be advantageous to attempt improved scheduling. While some areas will produce more solid waste during process upsets or other abnormal conditions, most generation points follow predictable patterns.

Definite route schedules based on a study of the individual mill's solid waste generation would insure adequate collection under normal conditions and would provide better equipment utilization to make collection of unpredicted solid waste less troublesome.

Overall, collection represents the most costly component of solid waste management in the pulp and paper industry. The physical collection and transportation of large volumes of solid waste material requires extensive expenditures for both equipment and labor. Later report sections will discuss the economic factors related to collection as well as other solid waste management functions.

Processing

Solid waste processing is limited in the pulp and paper industry. Use of stationary compactors, incinerators, shredders, etc. is normally confined to specific solid waste sources and most often is used when the material is to be utilized for resource recovery purposes. The major nonresource recovery processing activity is compaction of bulky solid waste material thus reducing the required collection frequency. These operations are becoming more common in specialty paper mills that produce significant quantities of nonpulpable broke, in shipping and receiving areas where large quantities of packaging material and wrapping trim are generated, and in integrated converting operations that generate waste packaging material. The other primary use of compaction equipment is to bale wastepaper that is not reusable within the mill, but that does have value on the secondary materials market. Other high volume solid wastes such as bark, ash, chemical recovery solid waste, etc. are of a dense nature and do not undergo significant compaction to justify the costs.

Size reduction is used primarily to reduce the particle size of combustible solid waste so that it may be burned to recover its heat value. Bark hogs or shredders are used extensively to reduce the bark particle size prior to entering the bark boilers. Size reduction equipment is also utilized on a minor scale to prepare other combustibles (wood, paper, etc.) for use in hog fuel boilers.

The other common operation that may be classified as size reduction is the pulping of broke and wastepaper to prepare it for reuse in the papermaking process. Nearly every mill in the nation has some type of facility capable of pulping broke and/or purchased wastepaper into slurry form. If this normal process step is considered as a solid waste processing technique it is easily the most prevalent processing activity in the pulp and paper industry.

Incineration is limited to a small number of mills that use this method to reduce the solid waste volume prior to final disposal or to handle special solid waste sources. The major increase in thermal processing is the use of incinerators to reduce the large wastewater treatment sludge volumes that must be hauled to normal disposal sites.

Bark consumption in steam and power boilers represents the largest use of potential solid waste as a fuel source. This activity will be discussed further as a resource recovery alternative.

Wastewater treatment sludge processing to lessen the quantity requiring disposal or to provide a material suited for combustion is practiced by some mills. Vacuum filters, centrifuges, belt and coil filters, and various presses have been applied to sludge dewatering. Also, sludge incineration is becoming an increasingly popular technique to reduce solid waste volumes and to recover energy value. The use of sludge processing techniques relative to sludge disposal will be discussed later in this chapter.

Disposal

Pulp and paper industry solid waste disposal is primarily characterized by land disposal sites. For the most part, these sites are partially controlled but do not meet sanitary landfill criteria. Most sites do undergo some degree of covering and in many instances dumping of specific solid waste materials is confined to designated areas. However, little or no site preparation or planning is normally evident, with most sites occupying land as near as possible to the mill site and simply spreading out from the mill's original disposal site.

Because of the nonputrescible nature of most of the industry's solid waste, solid waste management agencies have been quite lenient in providing operating licenses or permits for these industry's disposal site operations. Rather than apply sanitary landfill regulations, licenses are issued for industrial solid waste sites or other modifications of truly satisfactory disposal operations. Some agencies require separate disposal of any food wastes in order to satisfy industrial site classification criteria, but most have not required this activity to date.

Very little, if any actual testing has been done at most mill sites with regard to leachate contamination of ground or nearby surface waters. From visual observations, this problem does exist in some areas, particularly where bark or other organic solid wastes are placed in low lying areas subjected to standing groundwater. Also, chemical pulping or other active chemical solid wastes that come in contact with runoff or standing water can easily contribute to groundwater or surface water contamination. Primarily because of the usually remote location of large integrated pulp and paper mills plus strong emphasis on more obvious water pollution problems, this area of groundwater pollution has not received much attention either from regulatory authorities or mill officials.

Solid waste from mills using private contractors probably receive no better disposal than is received by mills with internal disposal operations. While municipal and private contractor's sites are being updated and forced to meet improved operational standards, the majority of disposal sites still fail to meet sanitary landfill criteria. Thus, whether the pulp and paper industry's solid waste is presently disposed of on-site or at private or municipal facilities, significant improvement will be required in the next decade to meet recommended guidelines.

Disposal of wastewater treatment plant sludge is a separate area that requires an increasing degree of industry attention. A detailed accounting of the industry's sludge disposal practices was not included in this study, but a review of previous EPA studies on wastewater treatment facilities, equipment manufacturers' installation data, Council of Economic Priorities report on the paper industry(11), and industry experience provided a basis for approximating sludge disposal practices (Table 2).

The trend in primary sludge handling and disposal methods is toward dewatering and land disposal or incineration because of the large land requirement for lagooning as well as the short life of lagoons. The lack of land close to mill production areas increases transportation charges thus making additional dewatering and/or incineration more economically attractive alternatives.

Secondary wastewater treatment sludge generation has been increasing, but it has not yet manifested itself as an industry wide solid waste problem. Most of the industry's existing secondary treatment operations employ aeration lagoons or other long detention time methods. Historically, these methods have not required secondary clarification to meet settlable solids guidelines, thus not creating a solid waste requiring collection and disposal. However, with new effluent guidelines, it is expected that secondary clarification and the related solid waste will become more prevalent in the industry. Because of the higher capital and operating costs, only a few activated sludge secondary treatment systems have been installed in the pulp and paper industry.

TABLE 2

ESTIMATED PRIMARY WASTEWATER TREATMENT SLUDGE HANDLING AND DISPOSAL PRACTICES*

Disposal Method	1958 (%)	1963 (%)	1967 (%)	1971 (%)	1975 (%)	1980 (%)
Lagoon	90.0	80.0	70.0	62.0	50.0	40.0
Landfill**	9.5	18.0	25.5	24.0	30.0	30.0
Thermal Processing**	0.5	2.0	4.5	14.0	20.0	30.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

*From Gorham International Inc. and Industry Data

**Landfill Plus Thermal Processing Is That Amount Dewatered

The few mills currently providing secondary clarification generally lagoon the resulting sludge. However, dewatering in conjunction with primary sludge for combustion is being successfully accomplished. At the present time, dewatering of secondary sludge and handling it as a solid waste for disposal is an essentially nonexistent practice.

Sludge disposal will receive increasing industry attention as wastewater treatment facilities expand, and major efforts will be undertaken to find new disposal techniques or feasible alternatives.

Resource Recovery

The degree of resource recovery practiced within the pulp and paper industry is significant. Several potential solid waste sources are routinely returned to the manufacturing process thus reducing the virgin raw material requirements.

The first point in the manufacturing process where a sizable amount of material enters a resource recovery stream is in the wood yard and wood room activities. Bark and associated wood wastes are diverted to a variety of boilers for use as fuel. This fuel source is continually becoming an increasing segment of the industry's energy supply. On an overall industry basis, energy from bark recovery accounts for about five percent of the total energy consumed (Table 3). This assumes the BTU value of bark at about 2.9 million kilocalories per metric ton (10.5 million BTU's per short ton). Actual bark quantities for this resource recovery function will be presented in the chapter discussing solid waste quantities (Chapter VI). Bark utilization activity entails major equipment installations designed to prepare the bark for combustion, to physically store and transport the bark to the boilers, and to provide boilers designed and equipped to provide adequate bark combustion. Important combustion variables and alternative designs will be discussed in the technology assessment chapter.

TABLE 3

ENERGY USAGE OF PULP AND PAPER INDUSTRY - 1971*

External Fuels	Consumption (MMMM BTU's)	Percent Of Total	Consumption (MMMM Kilocalories)
Oil - #5, #6	412.4	18	103.5
Oil - #2	27.7	1	7.0
Coal	373.7	17	93.8
Gas	568.7	25	142.7
Hogged Fuel	9.6	1	2.4
Propane	0.3	--	.1
Purchased Electricity	94.2	4	23.6
Subtotal	1,486.6	66	373.1
Internal Fuels			
Bark	111.7	5	28.0
Spent Liquor	667.0	29	167.5
Subtotal	778.7	34	195.5
TOTAL	2,265.3	100	568.6

*From Modified American Paper Institute Report (Sources and Utilization of Energy In The U. S. Pulp and Paper Industry - March, 1973)

Despite the prominence of bark burning in the pulp and paper industry, little technical information has been compiled and published concerning the design, operation or financial aspects of such operations. Individual companies and equipment suppliers are the two major sources of information, but even they have a surprisingly limited view of the overall operation. Equipment suppliers are generally involved in supplying only components of the overall system (boiler, storage bin, shredder, conveyors, etc.) and have little knowledge of exactly how their equipment meshes with other equipment or how it is actually being operated once it has been sold. Likewise, individual companies either engineer the total system or hire a design firm to provide the layout, and once in operation, few operating records or evaluations are made on the system as long as the bark is being consumed. Because of the many variables involved, some mills encounter great difficulty in burning their bark while another seemingly similar mill will have essentially no difficulty. Despite this lack of common knowledge and standard design or operational procedures, energy recovery from bark represents a resource recovery technique that diverts large quantities of material from routine disposal operations (4).

The most significant resource recovery technique in an economic sense for the industry's sulfate pulping segment is the use of recovery boilers to reclaim both heat and chemicals. While this process step is an essential portion of the manufacturing operation, it deserves mention because of the large quantity of dissolved organic solids that are burned for energy value (Table 3), thus allowing recovery of the valuable cooking chemicals that can then be reprocessed to produce cooking liquor to produce additional kraft pulp. If not consumed in this manner, the organic matter dissolved from the incoming wood would require treatment as wastewater resulting in additional sludge generation. Thus, indirectly, the recovery furnace operation does have an identifiable positive impact on total solid waste generation.

Other chemical pulping processes (sulfite, NSSC, etc.) also utilize recovery boiler operations to reclaim energy and chemical values, but not as extensively as do the kraft mills. Where more than one type of pulping operation is combined in a single mill, additional resource recovery operations are possible. Rejects from one system may be usable by introduction into a different

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[4], p.10-14.

type of chemical or mechanical pulping system. For example, groundwood tailings and bull screen rejects can be introduced to a sulfite cooking process. Similarly, screening rejects can sometimes be diverted to a refiner groundwood pulping operation. Also, within any pulping system, screening and cleaning rejects are normally recycled to receive additional refining, cooking, or other processing to enable maximum fiber yield. Because most of these recycle steps are automatic, no quantity data are kept concerning actual recycle rates. Only ultimate yields are of sufficient interest for most mills to determine on a routine basis.

In the papermaking area, another type of essential resource recovery is broke recovery. Broke pulpers to recover trim and other unsalable or off-specification paper are utilized in all types of papermaking operations. This equipment is routinely acquired as part of the capital expenditures for any new mill. Most operating duties and functions are part of the normal production crew's responsibilities with actual resource recovery costs intermingled with all the production costs. Depending upon the product being produced and actual operating conditions, up to 20 percent of the gross paper production may be recycled internally. Obviously, this quantity fluctuates greatly during periods of poor operation, order changes, start-ups, etc. However, even at the cited order of magnitude, loss of this material would disrupt the entire pulp and paper industry's economic structure.

The wastepaper sector of the pulp and paper industry is routinely involved in wastepaper utilization from many sources. One of these sources is virgin paper mills that generate broke that cannot be economically reused internally. This applies principally in the manufacture of highly coated papers. Mills making highly coated publication papers find it uneconomical to remove all the coating, fillers, etc. to reclaim the basic fiber for reuse. However, wastepaper mills producing various paperboard grades can use the highly coated broke without removing all the materials added by the coated paper manufacturers. Thus, assuming an economical transportation distance, highly coated broke may be reused in the secondary fiber industry.

Summary

This chapter has presented narrative describing the most commonly utilized solid waste management practices in today's pulp and paper industry. Basically, practices have focused on the most economical and conventional collection method to remove solid waste to a land disposal site. Disposal sites tend to be open dumps, at best partially controlled dumping grounds. Fortunately, because of the nature of the common solid waste materials and usually remote locations, pulp and paper industry solid waste disposal sites have not caused extensive pollution problems. However, increasing environmental legislation and continuing progress in control of more pressing industry pollution problems will bring increased pressure to bear on the industry's solid waste management activities.

The area of most significant pulp and paper industry solid waste management achievement is recovery of materials with economic value in overall production operations. Normal industry practices include recovery of energy from bark wastes, chemical and energy recovery from spent cooking liquors, fiber recovery from internal broke, and recovery of highly coated broke for use in secondary fiber mills.

CHAPTER VI

SOLID WASTE QUANTITIES

This chapter presents the estimated solid waste quantities for major generation activities. The total quantities presented in this chapter are based on estimates made by correlating solid waste generation with known industry production or raw material consumption data.

The 1971 data have been prepared on a regional basis to enable reporting all information on available industry production statistics. The four Department of Commerce regions (Table 4) for the pulp and paper industry have been used to provide correlation with the government statistics. The Department of Commerce's Southern region has been divided into South Atlantic and South Central subregions because of the large production in the Southern region.

Based on 1971 solid waste generation, industry growth, and projected industry patterns, both historical solid waste generation and projected generation are presented in this chapter. National totals have been compiled for the years 1958, 1963, 1967, 1971, and projected for the years 1975 and 1980. Historical production and consumption data published by the Bureau of Census, Department of Commerce, and the American Paper Institute were used to calculate totals. The same sources have published forecasts for the industry and these were used to generate projected values.

Wood Processing Solid Waste

The total quantity of bark generated varies depending on wood species, tree size, logging conditions, and mill operating conditions. Even within individual mills much confusion exists concerning bark generation quantities. However, based on actual studies conducted at different U. S. locations by individual mills, an average bark generation quantity of 50.1 to 56.4 bone-dry kilograms per cubic meter (400 to 450 bone-dry pounds per cord) of incoming roundwood represents a reasonable average. Up to about 25 percent of this waste can be made up of wood slivers and chunks removed during the actual debarking operation. Bark generation rates of up to 68.9 bone-dry kilograms per cubic meter (550 bone-dry pounds per cord) have been used for bark boiler design. However, this rate appears to be derived from design safety factor considerations rather than from actual bark generation studies. Regional and national bark

TABLE 4

REGIONAL DISTRIBUTION*

Northeast

Maine
New Hampshire
Vermont
Massachusetts
Rhode Island
Connecticut
New York
New Jersey
Pennsylvania

North Central

Ohio
Indiana
Illinois
Michigan
Wisconsin
Minnesota
Iowa
Missouri
North Dakota
South Dakota
Nebraska
Kansas

South Central

Kentucky
Tennessee
Alabama
Arkansas
Mississippi
Louisiana
Texas
Oklahoma

South Atlantic

Delaware
Maryland
District of Columbia
Virginia
West Virginia
North Carolina
South Carolina
Georgia
Florida

West

Montana
Idaho
Wyoming
Colorado
New Mexico
Arizona
Utah
Nevada
Washington
Oregon
California
Hawaii
Alaska

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*From Department of Commerce

generation quantities (Table 5) were based on either 50.1 or 56.4 kilograms per cubic meter (400 or 450 pounds per cord) depending on experience within each region. The Southern regions have the higher generation rates. This was attributed to the smaller diameter sticks plus the amount of heavy foreign material (soil, grit, etc.) brought into the mill with the wood.

The regional bark generation rates were applied to American Pulpwood Association statistics for roundwood usage to estimate total bark generation (Table 5).

The disposition of bark is continually changing and is difficult to quantify. Current emphasis within the industry is toward the use of bark as fuel, thus recovering available energy value (Table 6). A recent American Paper Institute survey of the U. S. pulp and paper industry energy sources indicated that 9,648,122 metric tons (12) (10,637,400 tons) of bark were utilized for fuel in 1971. Regional fluctuations in bark boiler utilization are rapidly diminishing with the installation of bark boiler equipment by most large bark generators. Difficulty in accurately determining bark consumption in boiler facilities arises from lack of measuring devices, fluctuating feed rates, and varying operational procedures. Thus, the API energy report represents the most extensive effort to date to estimate total bark boiler consumption for a specific time period.

Other uses of bark include compost, mulch, and other agricultural or horticultural products. Also, chemical extraction from bark and use as a structural product present potential resource recovery opportunities. However, most bark recovery processes are currently connected with the lumber industry with only a small percentage of the pulp and paper industry's bark flow reaching such resource recovery operations. Thus, these uses represent a negligible total on an overall industry basis.

Bark not utilized as fuel or other uses must be transported from the wood yard area to a disposal site. Even at most mills with bark burning equipment, a significant quantity of bark and grit is removed from the wood storage areas and from the log flume water clarifiers. That bark generally has a higher ash content and is more abrasive to conveying and combustion equipment than is bark direct from the debarking drums. However, some mills are building bark burning systems to remove contaminants and handle this general wood yard refuse that may contain up to 25 to 30 percent of the incoming bark.

TABLE 5

BARK GENERATION - 1971*

Region	Roundwood Consumption Softwood Cu Meters (Cords)	Roundwood Consumption Hardwood Cu Meters (Cords)	Bark Generation Rate Kg/Cu Meters (Dry Lb/Cord)
Northeast	10,723,000 (2,958,000)	6,634,000 (1,830,000)	50 (400)
North Central	5,068,000 (1,398,000)	9,806,000 (2,705,000)	50 (400)
South Atlantic	47,506,000 (13,105,000)	13,032,000 (3,595,000)	56 (450)
South Central	42,964,000 (11,852,000)	15,279,000 (4,215,000)	56 (450)
West	12,818,000 (3,536,000)	1,272,000 (351,000)	50 (400)
Total	119,079,000 (32,849,000)	46,023,000 (12,696,000)	

(Continued On Next Page)

TABLE 5
(continued)

Region	Bark Generation			
	Softwood Metric Tons (Tons)	Hardwood Metric Tons (Tons)	Total Dry Metric Tons (Dry Tons)	Total Wet Metric Tons (Wet Tons)
Northeast	536,581 (591,600)	331,962 (366,000)	868,543 (957,600)	1,737,086 (1,915,200)
North Central	253,597 (279,600)	490,687 (541,000)	744,284 (820,600)	1,488,568 (1,641,200)
South Atlantic	2,674,403 (2,948,625)	733,650 (808,875)	3,408,053 (3,757,500)	6,816,106 (7,515,000)
South Central	2,418,697 (2,666,700)	860,176 (948,375)	3,278,873 (3,615,075)	6,557,746 (7,230,150)
West	641,430 (707,200)	63,671 (70,200)	705,102 (777,400)	1,410,204 (1,554,800)
Total	6,524,708 (7,193,725)	2,480,146 (2,734,450)	9,004,855 (9,928,175)	18,009,710 (19,856,350)

*From American Pulpwood Association, American Paper Institute, and Gorham International Inc.

TABLE 6

DISPOSITION OF BARK - 1971*

Region	Total Consumed For Energy** Wet Metric Tons	Total Consumed For Energy Wet Tons	Total For Miscellaneous Uses and For Disposal** Wet Metric Tons	Total For Miscellaneous Uses and For Disposal Wet Tons
Northeast	816,391	900,100	920,696	1,015,100
North Central	383,117	422,400	1,105,451	1,218,800
South Atlantic	3,786,271	4,174,500	3,029,835	3,340,500
South Central	2,531,709	2,791,300	4,026,037	4,438,850
West	2,130,634	2,349,100	Unknown	Unknown
Total	9,648,122	10,637,400	9,082,019	10,013,250

*From American Pulpwood Association, American Paper Institute, and Gorham International Inc.

**Total Consumed For Energy Plus Total For Other Uses Do Not Equal Total Generation Because Of Excess Bark Combusted In West Region

Bark use from nonpulp and paper industry sources is receiving attention as an energy source. The Western region currently burns more bark than is received directly with its roundwood supplies. This results from the region's extensive use of residuals and the integration of lumber and pulp and paper mills (total forest product complexes). However, as is apparent from viewing the spillage and losses that occur in wood handling prior to debarking, the Western region still does transport some material to disposal. This quantity was not estimatable from available data and was considered negligible for study purposes. Similar energy recovery approaches are becoming increasingly popular in other regions with several areas currently planning new facilities to incorporate bark wastes from both sawmill and pulp mill operations.

For the national generation totals (Table 22), except in 1971 when regional quantities were compiled, a value of 53.2 kilograms of bone dry bark per cubic meter of roundwood (425 pounds per rough cord) was used to develop historic and projected values. It is felt that this rate per unit of roundwood will remain nearly constant through 1980. Minimum diameter sticks that can be debarked in drum debarkers are 8.9 centimeters (3.5 inches). Therefore more bark from smaller diameter sticks is being ruled out. Since the same motions are required to harvest a small diameter stick or a large diameter stick, it appears that harvest cycles will be used which produce the most wood per stick at the lowest cost. The trend to long log delivery to mills reflects a different mode of harvest, but does not indicate much change in solid waste generation. If anything, long log slashers at the mill site are creating a sawdust waste that previously remained in the woods.

The wood processing solid waste (Table 22) is listed as bark to disposal in wet tons. The 1958 and 1963 values are based on total roundwood usage. There is no historical data available to identify the amount of bark burned at the disposal site or the amount of peeled roundwood delivered to the mills. Each of these two practices was in existence and obviously reduced the bark to disposal values presented for the early years. The 1971 and 1975 values are based on industry data collected by API for its energy study. The national trend is shown as increasing through 1975 and declining by 1980. The 1980 quantities of bark to disposal reflect the increasing importance of bark as a fuel for steam and power generation and the desire to conserve useful space at disposal sites.

New concepts and technologies employing whole tree logging, chipping, and roughwood chip pulping are under investigation. These would shift the bark to disposal as solid waste to some other portion of the pulping process. In addition to these potential processes, continued growth in residuals use for pulping assures the industry a smaller bark dispcsal problem in future years.

Power Generation Solid Waste

Power generation solid waste is primarily ash resulting from the combustion of coal in the industry's power boilers plus the contribution from bark combustion (Table 7). Other fuels (oil and natural gas) contribute only very small amounts of ash to solid waste quantities. While oil and gas contain only minute quantities of noncombustibles, these will add to the solid waste load as air pollution emission controls are more strictly enforced. Coal ash was calculated from Department of Commerce coal usage data for the pulp and paper industry and collected ash values established by case studies and discussions with other coal consuming mills.

Bark ash was calculated from previously cited API bark boiler consumption statistics. A collected ash value of three percent was used for all regions. Bark ash varies considerably based on species, location, logging techniques, weather, storage, etc. Thus, the chosen figure may not be reasonable for some specific installations, but it represents a reasonable industry average. Also, additional bark material that is actually combustible may be escaping from boiler stacks due to barks peculiar combustion characteristics. Again, improved air pollution facilities will either provide for combustion of this material or it will be added to the solid waste load.

No physical count of the number of mills utilizing each type of fuel was conducted, but the total usage of fuel by region (Table 8) indicates the strong regional variations in fuel types used. An estimate of 1975 fuel consumption (Table 9) indicates the predicted changes in industry fuel consumption patterns. However, the influence of the existing energy crisis and fuel shortages may influence these predicted fuel usage trends.

TABLE 7

COAL AND BARK ASH - 1971*

Region	Coal Usage Metric Tons (Tons) x10³	Percent Ash Collected	Coal Ash Metric Tons (Tons)	Dry Bark Usage Metric Tons (Tons) x10³	Percent Ash Collected	Bark Ash Metric Tons (Tons)	Total Ash Metric Tons (Tons)
Northeast	1,180.9 (1,302.0)	12%	141,710 (156,240)	408 (450)	3%	12,246 (13,502)	153,956 (169,742)
North Central	5,694.2 (6,278.1)	15%	854,136 (941,715)	191 (211)	3%	5,747 (6,336)	859,882 (948,051)
South Atlantic	3,048.4 (3,361.0)	10%	304,843 (336,100)	1,893 (2,087)	3%	56,795 (62,618)	361,637 (398,718)
South Central	885.3 (976.1)	12%	106,239 (117,132)	1,266 (1,396)	3%	37,975 (41,869)	144,213 (159,001)
West	2,129.3 (2,347.6)	12%	255,513 (281,712)	1,066 (1,175)	3%	31,959 (35,236)	287,472 (316,948)
Total	12,938.1 (14,264.8)		1,662,441 (1,832,899)	4,824 (5,319)		144,722 (159,561)	1,807,160 (1,992,460)

*From Department of Commerce, American Paper Institute, and Gorham International Inc.

TABLE 8

REGIONAL FUEL CONSUMPTION - 1971*

Region	Oil (#5, #6) x10^3 Cu M (x10^3 Bbls)	Oil (#2) x10^3 Cu M (x10^3 Bbls)	Coal x10^3 Metric Tons (x10^3 Tons)	Gas x10^6 Cu M (x10^6 Cu Ft)	Bark x10^3 Metric Tons (x10^3 Tons)
Northeast	4,235.2 (26,636.3)	197.3 (1,241.1)	1,180.9 (1,302.0)	349.1 (12,329.7)	816.4 (900.1)
North Central	304.7 (1,916.2)	217.4 (1,367.6)	5,694.2 (6,278.1)	3,067.7 (108,335.6)	383.1 (422.4)
South Atlantic	4,179.6 (26,286.6)	52.8 (332.2)	3,048.4 (3,361.0)	1,102.5 (38,936.3)	3,786.3 (4,174.5)
South Central	700.6 (4,406.3)	184.3 (1,159.2)	885.3 (976.1)	7,888.9 (278,597.0)	2,531.7 (2,791.3)
West	988.9 (6,219.6)	82.9 (521.6)	2,129.3 (2,347.6)	2,230.3 (78,762.8)	2,130.6 (2,349.1)
Total	10,409.0 (65,465.0)	734.7 (4,621.7)	12,938.1 (14,264.8)	14,638.5 (516,961.4)	9,648.1 (10,637.4)

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TABLE 8

(Continued)

Region	Spent Liquor Solids $x10^3$ Metric Tons ($x10^3$ Tons)	Hogged Fuel $x10^3$ Metric Tons ($x10^3$ Tons)	Propane $x10^3$ Cu M ($x10^3$ Gal)	Purchased Electricity $x10^{11}$ Kg M ($x10^6$ Kw Hr)
Northeast	2,285.6 (2,520.0)	20.2 (22.3)	0.9 (236.8)	18,608.7 (5,069.1)
North Central	2,603.2 (2,870.1)	- -	3.0 (787.0)	18,725.0 (5,100.8)
South Atlantic	18,162.2 (20,024.5)	- -	1.4 (383.1)	14,974.4 (4,079.1)
South Central	13,347.2 (14,715.8)	1.1 (1.2)	5.0 (1,323.6)	20,200.4 (5,502.7)
West	8,750.1 (9,647.3)	462.8 (510.2)	1.0 (272.6)	29,190.3 (7,951.6)
Total	45,148.3 (49,777.7)	484.1 (533.7)	11.3 (3,003.1)	101,698.8 (27,703.3)

*From Revised API Energy Report

TABLE 9

ESTIMATED FUEL CONSUMPTION - 1975*

Region	Oil (#5, #6) $\times 10^3$ Cu M ($\times 10^3$ Bbls)	Oil (#2) $\times 10^3$ Cu M ($\times 10^3$ Bbls)	Coal $\times 10^3$ Metric Tons ($\times 10^3$ Tons)	Gas $\times 10^6$ Cu M ($\times 10^6$ Cu Ft)	Bark $\times 10^3$ Metric Tons ($\times 10^3$ Tons)
Northeast	4,938.4 (31,059.3)	260.8 (1,640.1)	882.3 (972.8)	414.9 (14,650.6)	1,301.4 (1,434.8)
North Central	714.6 (4,494.2)	304.1 (1,912.5)	4,413.9 (4,866.5)	3,525.7 (124,508.6)	517.2 (570.2)
South Atlantic	4,773.9 (30,024.8)	112.3 (706.5)	3,121.6 (3,441.7)	1,045.2 (36,911.1)	4,320.7 (4,763.7)
South Central	1,678.5 (10,556.5)	151.7 (953.8)	868.0 (957.0)	5,742.3 (202,789.0)	3,772.4 (4,159.2)
West	1,106.5 (6,959.3)	179.7 (1,130.5)	3,039.5 (3,351.2)	2,060.0 (72,747.7)	2,437.3 (2,687.2)
Total	13,211.9 (83,094.1)	1,008.6 (6,343.4)	12,325.3 (13,589.2)	12,788.1 (451,607.0)	12,349.0 (13,615.1)

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TABLE 9

(Continued)

Region	Spent Liquor Solids $x10^3$ Metric Tons ($x10^3$ Tons)	Hogged Fuel $x10^3$ Metric Tons ($x10^3$ Tons)	Propane $x10^3$ Cu M ($x10^3$ Gal)	Purchased Electrictiy $x10^{11}$ Kg M ($x10^6$ Kw Hr)
Northeast	2,503.4 (2,760.1)	43.5 (48.0)	1.1 (282.9)	20,730.9 (5,647.2)
North Central	2,627.6 (2,897.0)	- -	3.0 (788.7)	21,356.0 (5,817.5)
South Atlantic	20,048.7 (22,104.4)	- -	1.4 (383.1)	17,797.0 (4,848.0)
South Central	15,533.4 (17,126.1)	10.9 (12.0)	6.0 (1,588.3)	24,626.2 (6,708.3)
West	9,900.4 (10,915.5)	480.0 (529.2)	1.2 (318.3)	33,573.9 (9,145.7)
Total	50,613.5 (55,803.1)	534.4 (589.2)	12.7 (3,361.3)	118,084.0 (32,166.7)

*From Revised API Energy Report

The lack of information concerning bark boiler usage in the 1958, 1963, and 1967 time periods prevents reporting a specific value for those periods (Table 22). The 1967 value is a reasonable estimate based on Gorham knowledge of the industry practices at that time. The coal ash values were derived from Department of Commerce published industry data for coal consumption.

The future growth of bark ash quantities is quite certain as there are economic benefits gained from bark boilers. A growth of coal ash quantities is forecast for 1980 due to the vast coal reserves in this country, the competition for oil and gas, and the industry's power needs. Alternate sources of power are not available and not likely to exist before 1980 which would shift the industry away from coal use.

The lone problem associated with coal use is the sulfur content of the fuel and its contribution to air emission loads. Systems to curtail the surfur problem are under study but it is premature to conclude that sulfur dioxide control systems for 1980 will lead to increased solid waste loads.

Personnel Activity Solid Waste

The generation rate for this solid waste source is about 0.227 kilograms (0.5 lb) per employee per shift (Table 10). The total industry employment for 1971 was calculated based on 1971 employment as reported by the Department of Commerce, Bureau of Census in their annual M26 report. With the industry averaging about five and one-half days per employee per week, personnel activity solid waste was calculated based on 52 five-day weeks per employee with the half-day allowance being assumed to account for vacation time, sick leave, and other lost time.

While this solid waste source represents a small portion of the industry's total solid waste, it is generated at numerous sources throughout the mill thus complicating collection procedures, and it contains food scraps and garbage (putriscible material) that require attention to prevent odors during storage and leachate or pest problems at the disposal site. Thus, as a small solid waste quantity, it contributes an unproportional share of problems to the solid waste management system.

TABLE 10

PERSONNEL ACTIVITY SOLID WASTE - 1971*

Region	Percent Of Employees	Average Tons	Average Metric Tons
Northeast	17.6	3,207	2,909
North Central	19.1	3,488	3,164
South Atlantic	24.3	4,440	4,027
South Central	24.9	4,542	4,120
West	14.1	2,565	2,326
National Total	100.0	18,242	16,546

*From Gorham International Inc.

Little change is foreseen for this solid waste source, with minor increases resulting from increased employment and possibly slightly higher generation rates per employee. The national trend has been nearly stagnant for several years and is projected to show only a slight increase by 1980. Increased automation plus increased equipment size and speed has enabled greater production without significant personnel increase. The phasing out of marginal production units with low productivity and generally tight economic conditions have also led to personnel reductions that directly affect this solid waste category.

Wastewater Treatment Solid Waste

Wastewater sludge generation was calculated from the industry's total raw waste loads and reported levels of treatment. The raw waste loads reported in the technical literature vary greatly with different installations and operational conditions. For this study, raw waste loads (total suspended solids and BOD_5) were taken from a previous EPA study that presented standard raw waste loads based on industry sampling(13). The wide variations presented in raw waste load data carry directly through all calculations and are reflected in the final sludge quantities. To utilize the sludge data for additional calculations, Gorham International Inc. recommends that the average value of minimum and maximum numbers be used. This approach should provide results as near as possible to the overall industry averages. While discrepancies from the actual situation obviously exist with this approach, it does provide a method to approximate solid waste quantities and thus evaluate potential problem areas, alternative management strategies, and overall economic impact.

Once the total raw waste loads were calculated, the reported industry average discharge limits were deducted from total raw waste loads to estimate the amount of material removed during wastewater treatment processes.

For primary wastewater treatment, the estimated total suspended solids discharge per ton of production capacity was derived from various literature sources, discharge permit applications, mill data, proposed effluent standards, and related industry sources (Table 11). Based on Department of Commerce

TABLE 11

ESTIMATED EFFLUENT DISCHARGES*

	1958	1963	1967	1971	1975	1980
Total Suspended Solids:						
Kg/Metric Ton	50	43	33	23	10	5
Lb/Ton	100	85	65	46	20	10
BOD_5:						
Kg/Metric Ton	60	50	40	27	13	5
Lb/Ton	120	100	80	54	25	10

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*Estimated From Variety of Industry Information Sources And Gorham International Inc.

production statistics and estimated capacities of 60,800,000 metric tons (67,000,000 tons) in 1975 and 73,500,000 metric tons (81,000,000 tons) in 1980, the estimated annual industry discharges were calculated (discharge per unit of production times production). The difference between these estimated discharges and total raw waste loads was then assumed to be the suspended solids removed by the industry's primary wastewater treatment processes for each time period. Previously presented sludge deposition estimates (Table 2) were applied to these sludge generation numbers to determine the amounts of primary sludge requiring handling in the solid waste management system (Table 12). The regional data breakdown presented for 1971 was calculated as being proportional to the total regional wood pulp consumption in 1971.

To obtain the total primary wastewater treatment solid waste, sludge incineration ash was added to the dewatered sludge transported to land disposal (Table 13). For clarity purposes, these two solid waste categories are presented separately in the 1971 regional summary and in the national summary (Tables 21 & 22)

Secondary wastewater treatment generates less total weight of sludge than primary treatment, but it is more difficult to dewater and handle. As done with primary wastewater treatment, the total industry raw waste loads were calculated based on production statistics and estimates in conjunction with data on raw waste loads. Similarly, wide data ranges carry through to give wide ranges of secondary sludge quantities. If desiring to carry out additional industry wide calculations the average of minimum and maximum will provide the most realistic results.

The total raw waste loads were then reduced by a percentage to reflect the BOD_5 removed by primary treatment. The percentage of total BOD_5 removed was estimated to reflect the degree of primary treatment at the time under consideration. Thirty-five percent BOD_5 removal by primary treatment was considered as a maximum for the overall industry. This figure was increased from fifteen percent in 1958, to twenty percent in 1963, to twenty-five percent in 1969, and finally to the thirty-five percent level in 1971. The BOD_5 remaining after this primary treatment reduction is the BOD_5 input to the industry's secondary treatment systems.

The difference between the above calculated BOD_5 input to secondary treatment and industry's BOD_5 discharge (Table 11) represents the BOD_5 removed by secondary wastewater treatment processes.

TABLE 12

WASTEWATER TREATMENT SLUDGE - 1971*

	Northeast		North Central		South Atlantic	
	Minimum**	Maximum**	Minimum**	Maximum**	Minimum**	Maximum**
Primary Sludge To Lagoons	171,165 (188,716)	366,967 (404,594)	130,429 (143,803)	279,633 (308,305)	234,879 (258,963)	503,568 (555,202)
Primary Sludge To Combustion	23,840 (26,285)	51,113 (56,354)	16,380 (18,059)	35,116 (38,717)	122,569 (135,137)	262,780 (289,724)
Primary Sludge Dewatered And Handled As Solid Waste	29,061 (32,041)	62,306 (68,695)	77,258 (85,180)	165,637 (182,621)	117,440 (129,482)	251,784 (277,601)
Total Primary Sludge***	224,067 (247,042)	480,386 (529,643)	224,067 (247,042)	480,386 (529,643)	474,889 (523,582)	1,018,132 (1,122,527)

(Continued On Next Page)

TABLE 12
(Continued)

	South Central		West		Total	
	Minimum**	Maximum**	Minimum**	Maximum**	Minimum**	Maximum**
Primary Sludge To Lagoons	353,530 (389,779)	757,945 (835,662)	143,808 (158,554)	308,317 (339,931)	1,033,812 (1,139,815)	2,216,430 (2,443,694)
Primary Sludge To Combustion	60,396 (66,589)	129,486 (142,763)	16,370 (18,048)	35,095 (38,693)	239,555 (264,118)	513,590 (566,251)
Primary Sludge Dewatered And Handled As Solid Waste	86,045 (94,868)	184,476 (203,391)	88,971 (98,094)	190,748 (210,307)	398,776 (439,665)	854,951 (942,614)
Total Primary Sludge***	499,971 (551,236)	1,071,906 (1,181,815)	249,149 (274,696)	534,160 (588,931)	1,672,143 (1,843,598)	3,584,971 (3,952,559)

*From EPA, NCASI, Department of Commerce, Gorham International Inc., and Other Industry Sources

**Ranges Result From Raw Waste Load Data - Use Average For Calculations (See Page 60)

***All Weights On Dry Basis

All Weight Expressed In Metric Tons (Tons)

TABLE 13

TOTAL PRIMARY WASTEWATER TREATMENT SOLID WASTE - 1971*

	Northeast		North Central		South Atlantic	
	Minimum**	Maximum**	Minimum**	Maximum**	Minimum**	Maximum**
Sludge Handled As Solid Waste (Dry Weight To Land Disposal)	29,061 (32,041)	62,306 (68,695)	77,258 (85,180)	165,637 (182,621)	117,440 (129,482)	251,784 (277,601)
Water Transported To Disposal When Sludge Averages 33% Solids Or 67% Water	58,122 (64,082)	124,613 (137,390)	154,517 (170,360)	331,274 (365,242)	234,880 (258,964)	503,568 (555,202)
Total Wet Weight To Disposal If Sludge Averages 33% Solids	87,183 (96,123)	186,919 (206,085)	231,775 (255,540)	496,911 (547,863)	352,320 (388,446)	755,352 (832,803)
Sludge Ash*** (90% Weight Reduction By Sludge Incinerators)	2,384 (2,628)	5,111 (5,635)	1,638 (1,806)	3,512 (3,872)	12,257 (13,514)	26,278 (28,972)
TOTAL Primary Wastewater Treatment Solid Waste (Wet Weight)	89,567 (98,751)	192,030 (211,720)	233,413 (257,346)	500,423 (551,735)	364,577 (401,960)	781,630 (861,775)

(Continued On Next Page)

TABLE 13
(Continued)

	Minimum**	Maximum**	Minimum**	Maximum**	Minimum**	Maximum**
Sludge Handled As Solid Waste (Dry Weight To Land Disposal)	86,045 (94,868)	184,476 (203,391)	88,971 (98,094)	190,748 (210,307)	398,775 (439,665)	854,951 (942,615)
Water Transported To Disposal When Sludge Averages 33% Solids Or 67% Water	172,091 (189,736)	368,951 (406,782)	177,943 (196,188)	381,497 (420,614)	797,553 (879,330)	1,709,903 (1,885,230)
Total Wet Weight To Disposal If Sludge Averages 33% Solids	258,136 (284,604)	553,427 (610,173)	266,914 (294,282)	572,245 (630,921)	1,196,328 (1,318,995)	2,564,854 (2,827,845)
Sludge Ash*** (90% Weight Reduction By Sludge Incinerators)	6,040 (6,659)	12,948 (14,276)	1,637 (1,805)	3,509 (3,869)	23,956 (26,412)	51,358 (56,624)
TOTAL Primary Wastewater Treatment Solid Waste (Wet Weight)	264,176 (291,263)	566,375 (624,449)	268,551 (296,087)	575,754 (634,790)	1,220,284 (1,345,407)	2,616,212 (2,884,469)

*From EPA, NCASI, Department of Commerce, Gorham International Inc., And Other Industry Sources

**Ranges Result From Raw Waste Load Data - Use Average For Calculations (See Page 60)

***Weight Expressed As Actual Weight Transported To Disposal (Air-Dry)

All Weight Expressed in Metric Tons (Tons)

Based on total BOD_5 removal by the industry's prevalent methods, actual solids generation will approximate 0.1 kilogram per kilogram (0.2 lb per lb) of BOD_5 removed.

With current industry secondary wastewater treatment practices (primarily lagoon facilities), most mills do not provide secondary clarification equipment to remove this solid material. Only those mills with activated sludge and modifications of activated sludge concentrate this solid matter so that it must be either continuously or periodically removed. Among those installations that do collect this sludge, the most prevalent disposal method is sludge lagoons where further natural dewatering is attempted. However, dewatering of secondary sludge combined with primary sludge is being accomplished to provide a sludge suitable for incineration.

The quantity of secondary wastewater treatment sludge entering the solid waste system has historically been so small that it was considered negligible up to 1975 even though small quantities were being handled in 1971. The potential secondary sludge values are significant particularly when considering the difficulty encountered handling the material. When reviewing the dry solids potential for 1971 (Table 14), it should be considered that reaching a solids content of twenty percent for this material is difficult. Thus, the weight of water that could require transportation to disposal is a major consideration when choosing solid waste management alternatives. For 1975 calculations it was assumed that ten percent of the total potential secondary sludge solids would be dewatered for land disposal while twenty percent was assumed for 1980. No secondary wastewater treatment sludge ash figures were presented because of the minor contribution it is expected to make.

The wastewater treatment solid waste source is the industry's second largest and is increasing as liquid effluent requirements become more stringent. Primary sludge has shown a steady increase and secondary sludge will rapidly increase between now and 1980 (Table 22). With these national trends, wastewater treatment sludges will surpass wood yard solid wastes as the largest single source by 1980. Future efforts to decrease internal solids losses may help lessen the growth of wastewater treatment sludge quantities, but a steady increase is unavoidable.

TABLE 14

SECONDARY WASTEWATER TREATMENT SLUDGE SOLIDS - 1971*

	Minimum**		Maximum**	
Region	Metric Tons	Tons	Metric Tons	Tons
Northeast	1,248	1,376	27,842	30,697
North Central	1,248	1,376	27,842	30,697
South Atlantic	2,645	2,916	59,009	65,060
South Central	2,784	3,070	62,126	68,496
West	1,388	1,530	30,959	34,133
Total	9,313	10,268	207,778	229,083

*From EPA, NCASI, And Gorham International Inc., and Various Industry Sources

**Ranges Result From Raw Waste Load Data - Use Average For Calculations (See Page 60)

Manufacturing Services Solid Waste

This industry wide solid waste generation source varies depending on what internal services are provided, but it averages between 1.5 and 3.0 kilograms per metric ton (3 to 6 lb per ton) of final production. Other factors that influence total quantities are the extent of mill programs to eliminate wasteful practices, the method of wrapping and shipping the final product, the number and type of service shops operated, and other individual mill conditions.

The amount of manufacturing service waste collected each year (Tables 15 & 22) increases proportional to production. The forecast is for continued increases. As the cost of solid waste management increases due to greater cost at the disposal site and longer hauling distances, the solid waste from manufacturing services should receive greater scrutiny for resource recovery. Salvage, fiber potential, or fuel value should be considered as alternatives. The ease of segregation early in the collection cycle will be an asset in handling this solid waste source. However, even if resource recovery is accomplished at this source, the total volume reduction will not be large enough to cause much impact, if any, on the industry's total solid waste load.

Wastepaper Reclamation

Fluctuations in solid waste generation rates for this category occur with different wastepaper grades, sources, and processing operations. An average ratio of 91 kilograms (100 lb) of final product per 106 kilograms (117 lb) of wastepaper utilized presents a reasonable solid waste generation rate for all wastepaper operations except deinking.

For the deinking grades, about 127 kilograms (140 lbs) of wastepaper are required to produce 91 kilograms (100 lbs) of product.

Solid waste generated by mills utilizing wastepaper (Table 16) is concentrated in the Northeast and North Central regions with lesser contributions from each of the other three regions. This regional pattern exists for deinking mill solid waste as well as for all other wastepaper mills which represent the major production and waste quantities.

TABLE 15

MANUFACTURING SERVICES SOLID WASTE - 1971*

Region	Minimum Tons	Minimum Metric Tons	Maximum Tons	Maximum Metric Tons
Northeast	14,525	13,174	33,891	30,739
North Central	15,797	14,328	36,860	33,432
South Atlantic	20,115	18,244	46,935	42,570
South Central	20,580	18,666	48,020	43,554
West	11,620	10,539	27,114	24,592
National Total	82,637	74,951	192,820	174,887

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*From Gorham International Inc.

TABLE 16

WASTEPAPER RECLAMATION SOLID WASTE - 1971*

Deinking

Region	Minimum Tons	Minimum Metric Tons	Maximum Tons	Maximum Metric Tons
Northeast	76,979	69,820	85,428	77,483
North Central	116,254	105,442	128,857	116,873
South Atlantic	5,656	5,130	6,286	5,701
South Central	5,027	4,559	5,714	5,183
West	13,825	12,539	15,429	13,994
National Subtotal	217,741	197,490	241,714	219,234
All Other Wastepaper Processing				
Northeast	520,101	471,732	576,982	523,323
North Central	532,085	482,601	590,350	535,447
South Atlantic	140,931	127,824	156,342	141,802
South Central	125,272	113,622	138,905	125,987
West	168,733	153,041	187,145	169,741
National Subtotal	1,487,122	1,348,820	1,649,724	1,496,300
National Total	1,704,863	1,546,310	1,891,438	1,715,534

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*From Department of Commerce, Institute of Paper Chemistry, and Gorham International Inc.

The minimum and maximum quantities identified for each region in 1971 do not reflect generation rate differences as found in most other solid waste categories. Rather, the minimum was obtained by applying solid waste generation factors to Department of Commerce statistics, while maximum values resulted from utilization of Institute of Paper Chemistry industry survey statistics.

The national trend is increasing in tonnage each year in line with the increase in collection and reuse of wastepapers. The long term outlook is for an acceleration of this form of fiber collection. One factor that will affect growth beyond a certain point for this solid waste area is the export market for wastepaper. When a ton of repulped wastepaper yields more fiber than a ton of woodchips and the cost factors are correct, export demands will siphon away part of this solid waste source. Another unknown factor is the impact of government incentives to increase wastepaper reuse. Government incentive and impact studies are in progress and will not be reported on for some time. These could play a major role in increasing or decreasing activities in the wastepaper processing business.

Chemical Pulping Solid Waste

For U. S. kraft mills this source of solid waste averages between 15 and 20 kilograms per metric ton (30 to 40 lbs per ton) of pulp production. In sulfite pulp mills with recovery, solid waste generation averages about 5 kilograms per metric ton (10 lbs per ton) of pulp production. In some cases, portions of these solid wastes are deposited into the wastewater system for removal rather than segregated for separate collection.

The chemical pulping industry also utilizes a large amount of dissolved solids for heat value by combusting them in the recovery furnace. The recent API energy survey reported total 1971 U. S. consumption of spent liquor solids in recovery furnaces as 45,148,375 metric tons (49,777,700 tons). This combustion represents processing and recovery of materials that would otherwise be wasted and require some other type of collection and disposal, and would eliminate present pulping operations on an economic basis.

Regionally, this solid waste is concentrated in the regions with the greatest pulp production (Table 17). For the sulfate sector, the South Atlantic and South Central regions generate the greatest solid waste quantities. For the sulfite sector, the West region has the greatest generation with the combined Northeast and North Central about equaling the West region. The South Atlantic and South Central regions contribute no significant solid waste to the sulfite total.

The national trend for kraft pulping waste is increasing as most of the new pulping installations are of the kraft type. The sulfite solid waste trend has been decreasing in recent years and the trend is expected to continue as more and more mills shut down operations rather than install waste treatment facilities for small production tonnages.

The long term outlook regarding chemical pulping is unsettled at present. There is considerable activity aimed at nonsulfur based processes. However, it is almost a certainty that if any successful change occurs before 1980 it will have to operate in existing equipment and will have little effect on solid waste quantities.

Groundwood Pulping Solid Waste

Based on wood and operating conditions, this solid waste source for groundwood operations varies from 2.5 to 5 kilograms per metric ton (5 to 10 lbs per ton) of groundwood pulp production.

The largest quantity is generated in the South Central region followed by the Northeast, West, South Atlantic, and North Central regions (Table 18).

The national trend has shown a small increase up to 1971, but this should plateau with the introduction of refiner groundwood, and no new stone groundwood processes being built.

TABLE 17

CHEMICAL PULPING SOLID WASTE - 1971*

Sulfate

Region	Minimum Tons	Minimum Metric Tons	Maximum Tons	Maximum Metric Tons
Northeast	22,601	20,499	30,136	27,333
North Central	13,935	12,639	18,580	16,852
South Atlantic	177,968	161,417	237,290	215,222
South Central	163,703	148,479	218,271	197,972
West	68,171	61,831	90,894	82,441
Total Sulfate	446,378	404,865	595,171	539,820

Sulfite

Region	Average Tons	Average Metric Tons
Northeast	2,297	2,083
North Central	2,894	2,625
South Atlantic	3,218	2,919
South Central	1,338	1,214
West	9,113	8,265
Total Sulfite	18,860	17,106

*From Department of Commerce and Gorham International Inc.

TABLE 18

GROUNDWOOD PULPING SOLID WASTE - 1971*

Region	Minimum Tons	Minimum Metric Tons	Maximum Tons	Maximum Metric Tons
Northeast	2,689	2,439	5,378	4,878
North Central	1,344	1,219	2,687	2,437
South Atlantic	1,472	1,335	2,944	2,670
South Central	3,691	3,348	7,383	6,696
West	1,959	1,777	3,918	3,554
National Total	11,155	10,118	22,310	20,235

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*From Department of Commerce and Gorham International Inc.

Residuals Handling Solid Waste

Normal losses occurring during residuals handling vary depending on unloading methods, storage and conveyance methods, degree of screening, and other local considerations. Most operations will fall between 0.44 to 0.48 kilograms per cubic meter (3.5 to 7.0 lbs per cord) of residuals used.

With the high percentage of residuals used as raw material, the West is considerably higher in this category than any other region. The other regions follow in the order of South Central, South Atlantic, North Central, Northeast (Table 19). As wood supplies become tighter and increased wood utilization is practiced, this solid waste source will most likely increase in all regions. However, the tight wood supply may also lead to utilization of any wood chunks that are currently removed as solid waste. Despite such improvements, the increased use of residuals is expected to keep this solid waste quantity on the rise.

Specialty Paper Products Manufacturing Solid Waste

Solid waste from this source normally results from the addition of materials to obtain desired product characteristics. No specific industry data is available to determine precisely what quantity of material exists in this solid waste category. The difficulty of estimating is compounded by the fact that what one mill treats as solid waste another mill may reuse or sell as wastepaper. This discrepancy results in the quantities required to make repulping and cleaning economically feasible and the proximity of specialty products manufacturing facilities to wastepaper mills capable of using their waste type. To approximate the total solid waste in this category (Table 20), solid waste generation rates and production data for specific grades were estimated. The regional distribution was based on the approximate regional production of specialty paper grades. These grades often employ protected technology and are limited to a small number of manufacturing facilities. Thus, none of the production data obtained for specific grades is presented. The primary products that contribute to the nonpulpable broke making up specialty product solid waste are glassine, zinc oxide coated office copy papers, solvent coated papers, high wet strength papers (bumper stickers, map paper, outdoor advertisement papers, etc.), plastic coated paperboard, parchment, and special industrial packaging papers.

TABLE 19

RESIDUALS HANDLING SOLID WASTE - 1971*

Region	Minimum Tons	Minimum Metric Tons	Maximum Tons	Maximum Metric Tons
Northeast	1,573	1,427	3,146	2,853
North Central	1,008	914	2,016	1,829
South Atlantic	7,411	6,722	14,822	13,444
South Central	7,455	6,762	14,910	13,523
West	16,849	15,282	33,698	30,564
National Total	34,296	31,107	68,592	62,213

From American Pulpwood Association and Gorham International Inc.

TABLE 20

SPECIALTY PAPER PRODUCTION SOLID WASTE - 1971*

Region	Percent of Specialty Product Output	Solid Waste** Tons	Solid Waste** Metric Tons
Northeast	40	52,186	47,333
North Central	40	52,186	47,333
South Atlantic	5	6,523	5,916
South Central	5	6,523	5,916
West	10	13,047	11,834
National Total	100	130,465	118,332

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*From Gorham International Inc.

**This Solid Waste Includes Only That From Paper Mills Manufacturing Specialty Products (Does Not Include Associated Pulp Mill Solid Waste)

The national trend for this solid waste is increasing annually. However, this source exists only because of a number of products that are sold to consumers or industrial and business customers. For this reason, the long term outlook for this solid waste source is not definite. The constant introduction of new products brings with it the possibility of repulping the new item and eliminating the old waste source. While the present trend for solid waste from specialty products manufacture is growing, there is no certainty that it will continue. A shift to incineration for power generation or evaluation of other resource recovery activities could reduce the total amount of waste from this source.

Summary

The total solid waste generation determined for 1971 (Table 21) indicates that the magnitude of the total problem does vary regionally. The most noticeable pattern is the small total for the Western region. The high residuals usage and high degree of bark consumption for power cause this pattern. The actual total may be slightly higher than indicated due to some mills not burning one hundred percent of their own bark, but the region's high bark consumption would make any increase small compared to the total solid waste load. The South Central and South Atlantic regions lead the U. S. in solid waste generation. This position results from their leading production position. The North Central and Northeast regions occupy a position between the above high and low regions.

The national totals (Table 22) for all solid waste sources reflect an increasing tendency for the time period analyzed. The individual sources exhibit varying behavior depending on industry growth rate, employment, economics, and legislative requirements. In some instances, the generation rate per unit of production is constant, while the disposal method changes with time. In other cases the generation rate per unit of production may be changing due to process modifications and improvements.

Overall the solid waste quantity to disposal per unit of production exhibits a downward trend (Table 23). This indicates that the paper industry is optimizing its raw materials use and is attempting to further refine the integrated forest products complex concept.

TABLE 21

REGIONAL SOLID WASTE QUANTITIES - 1971*

Solid Waste Category	Northeast		North Central		South Atlantic		South Central		West		Total	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Bark To Disposal As Solid Waste	920,696 (1,015,100)	920,696 (1,015,100)	1,105,451 (1,218,800)	1,105,451 (1,218,800)	3,029,835 (3,340,500)	3,029,835 (3,340,500)	4,026,037 (4,438,850)	4,026,037 (4,438,850)	NE** NE**	NE** NE**	9,082,019 (10,013,250)	9,082,019 (10,013,250)
Bark Ash	12,246 (13,502)	12,246 (13,502)	5,747 (6,336)	5,747 (6,336)	56,795 (62,618)	56,795 (62,618)	37,975 (41,869)	37,975 (41,869)	31,959 (35,236)	31,959 (35,236)	144,722 (159,561)	144,722 (159,561)
Coal Ash	141,710 (156,240)	141,710 (156,240)	854,136 (941,715)	854,136 (941,715)	304,843 (336,100)	304,843 (336,100)	106,239 (117,132)	106,239 (117,132)	255,513 (281,712)	255,513 (281,712)	1,662,441 (1,832,899)	1,662,441 (1,832,899)
Personnel Activity	2,909 (3,207)	2,909 (3,207)	3,164 (3,488)	3,164 (3,488)	4,027 (4,440)	4,027 (4,440)	4,120 (4,542)	4,120 (4,542)	2,326 (2,565)	2,326 (2,565)	16,546 (18,242)	16,546 (18,242)
Primary Sludge To Disposal (Wet) As Solid Waste	87,183 (96,123)	186,919 (206,085)	231,775 (255,540)	496,911 (547,863)	352,320 (388,446)	755,352 (832,803)	258,136 (284,604)	553,427 (610,173)	266,914 (294,282)	572,245 (630,921)	1,196,328 (1,318,995)	2,564,854 (2,827,845)
Primary Sludge Ash	2,384 (2,628)	5,111 (5,635)	1,638 (1,806)	3,512 (3,872)	12,257 (13,514)	26,278 (28,972)	6,040 (6,659)	12,948 (14,276)	1,637 (1,805)	3,509 (3,869)	23,956 (26,412)	51,358 (56,624)
Manufacturing Services	13,174 (14,525)	30,739 (33,891)	14,328 (15,797)	33,432 (36,860)	18,244 (20,115)	42,570 (46,935)	18,666 (20,580)	43,554 (48,020)	10,539 (11,620)	24,592 (27,114)	74,951 (82,637)	174,887 (192,820)
Wastepaper Reclamation (Deinking)	69,820 (76,979)	77,483 (85,428)	105,442 (116,254)	116,873 (128,857)	5,130 (5,656)	5,701 (6,286)	4,559 (5,027)	5,183 (5,714)	12,539 (13,825)	13,994 (15,429)	197,490 (217,741)	219,234 (241,714)
(All Other)	471,732 (520,101)	523,323 (576,982)	482,601 (532,085)	535,447 (590,350)	127,824 (140,931)	141,802 (156,342)	113,622 (125,272)	125,987 (138,905)	153,041 (168,733)	169,741 (187,145)	1,348,820 (1,487,122)	1,496,300 (1,649,724)
Chemical Pulping (Sulfate)	20,499 (22,601)	27,333 (30,136)	12,639 (13,935)	16,852 (18,580)	161,417 (177,968)	215,222 (237,290)	148,479 (163,703)	197,972 (218,271)	61,831 (68,171)	82,441 (90,894)	404,865 (446,378)	539,820 (595,171)
(Sulfite)	2,083 (2,297)	2,083 (2,297)	2,625 (2,894)	2,625 (2,894)	2,919 (3,218)	2,919 (3,218)	1,214 (1,338)	1,214 (1,338)	8,265 (9,113)	8,265 (9,113)	17,106 (18,860)	17,106 (18,860)
Groundwood Pulping	2,439 (2,689)	4,878 (5,378)	1,219 (1,344)	2,437 (2,687)	1,335 (1,472)	2,670 (2,944)	3,348 (3,691)	6,696 (7,383)	1,777 (1,959)	3,554 (3,918)	10,118 (11,155)	20,235 (22,310)
Residuals Handing Loss	1,427 (1,573)	2,853 (3,146)	914 (1,008)	1,829 (2,016)	6,722 (7,411)	13,444 (14,822)	6,762 (7,455)	13,523 (14,910)	15,282 (16,849)	30,564 (33,698)	31,107 (34,296)	62,213 (68,592)
Specialty Products Manufacturing	47,333 (52,186)	47,333 (52,186)	47,333 (52,186)	47,333 (52,186)	5,916 (6,523)	5,916 (6,523)	5,916 (6,523)	5,916 (6,523)	11,834 (13,047)	11,834 (13,047)	118,332 (130,465)	118,332 (130,465)
TOTAL Solid Waste To Disposal	1,795,635 (1,979,751)	1,985,616 (2,189,213)	2,869,012 (3,163,188)	3,225,749 (3,556,504)	4,089,584 (4,508,912)	4,607,374 (5,079,793)	4,741,113 (5,227,245)	5,140,791 (5,667,906)	833,457 (918,917)	1,210,537 (1,334,661)	14,328,801 (15,798,013)	16,170,067 (17,828,077)

*From Gorham International Inc. and Previous References

**Not Estimatable

All Weight Expressed In Metric Tons (Tons)

TABLE 22

TOTAL SOLID WASTE QUANTITIES - 1958 THRU 1980*

Solid Waste Category	1958 Minimum	1958 Maximum	1963 Minimum	1963 Maximum	1967 Minimum	1967 Maximum	1971 Minimum	1971 Maximum	1975 Minimum	1975 Maximum	1980 Minimum	1980 Maximum
Bark To Disposal As Solid Waste	6,774,000 (7,468,000	6,774,000 (7,468,000)	8,620,000 (9,504,000)	8,620,000 (9,504,000)	9,016,000 (9,940,000)	9,016,000 (9,940,000)	9,082,019 (10,013,250)	9,082,019 (10,013,250)	9,387,000 (10,350,000)	9,387,000 (10,350,000)	7,204,000 (7,943,000)	7,204,000 (7,943,000)
Bark Ash	NE** NE**	NE** NE**	NE** NE**	NE** NE**	90,000 (99,000)	90,000 (99,000)	144,722 (159,561)	144,722 (159,561)	185,000 (204,000)	185,000 (204,000)	267,000 (294,000)	267,000 (294,000)
Coal Ash	1,398,000 (1,541,000)	1,398,000 (1,541,000)	1,565,000 (1,726,000)	1,565,000 (1,726,000)	1,410,000 (1,555,000)	1,410,000 (1,555,000)	1,662,441 (1,832,899)	1,662,441 (1,832,899)	2,018,000 (2,225,000)	2,018,000 (2,225,000)	2,439,000 (2,689,000)	2,439,000 (2,689,000)
Personnel Activity	16,000 (18,000)	16,000 (18,000)	16,000 (18,000)	16,000 (18,000)	17,000 (19,000)	17,000 (19,000)	16,546 (18,242)	16,546 (18,242)	17,000 (19,000)	17,000 (19,000)	18,000 (20,000)	18,000 (20,000)
Primary Sludge To Disposal (Wet) As Solid Waste	52,000 (57,000)	448,000 (495,000)	268,000 (296,000)	1,009,000 (1,112,000)	782,000 (862,000)	2,034,000 (2,243,000)	1,196,328 (1,318,995)	2,564,854 (2,827,845)	2,543,000 (2,804,000)	4,649,000 (5,126,000)	3,405,000 (3,754,000)	5,951,000 (6,561,000)
Primary Sludge Ash	NE** NE**	1,000 (1,000)	1,000 (1,000)	4,000 (4,000)	5,000 (5,000)	12,000 (13,000)	23,956 (26,412)	51,358 (56,624)	56,000 (62,000)	103,000 (114,000)	116,000 (128,000)	200,000 (221,000)
Secondary Sludge To Disposal (Wet) As Solid Waste	NE** NE**	NE** NE**	NE** NE**	NE** NE**	NE** NE**	NE** NE**	NE** NE**	NE** NE**	327,000 (360,000)	691,000 (762,000)	1,214,000 (1,339,000)	2,088,000 (2,302,000)
Manufacturing Services	42,000 (46,000)	98,000 (108,000)	54,000 (59,000)	124,000 (137,000)	63,000 (70,000)	149,000 (164,000)	74,951 (82,637)	174,887 (192,820)	92,000 (101,000)	213,000 (235,000)	113,000 (125,000)	199,000 (219,000)
Wastepaper Reclamation (Deinking)	157,000 (173,000)	157,000 (173,000)	174,000 (192,000)	174,000 (192,000)	180,000 (198,000)	180,000 (198,000)	197,490 (217,741)	219,234 (241,714)	284,000 (313,000)	284,000 (313,000)	397,000 (438,000)	397,000 (438,000)
(All Other)	1,062,000 (1,171,000)	1,062,000 (1,171,000)	1,178,000 (1,299,000)	1,178,000 (1,299,000)	1,212,000 (1,336,000)	1,212,000 (1,336,000)	1,348,820 (1,487,122)	1,469,300 (1,649,724)	1,920,000 (2,117,000)	1,920,000 (2,117,000)	2,687,000 (2,962,000)	2,687,000 (2,962,000)
Chemical Pulping (Sulfate)	173,000 (191,000)	231,000 (255,000)	[illegible] (3[illegible]00)	369,000 (407,000)	328,000 (362,000)	438,000 (483,000)	404,865 (446,378)	539,820 (595,171)	476,000 (525,000)	634,000 (699,000)	555,000 (612,000)	740,000 (816,000)
(Sulfite)	15,000 (16,000)	15,000 (16,000)	18,000 (20,000)	18,000 (20,000)	20,000 (22,000)	20,000 (22,000)	17,106 (18,860)	17,106 (18,860)	17,000 (19,000)	17,000 (19,000)	17,000 (19,000)	17,000 (19,000)
Groundwood Pulping	6,000 (7,000)	13,000 (14,000)	8,000 (9,000)	16,000 (18,000)	9,000 (10,000)	17,000 (19,000)	10,118 (11,155)	20,235 (22,310)	13,000 (14,000)	24,000 (27,000)	15,000 (16,000)	28,000 (31,000)
Residuals Handling Loss	9,000 (10,000)	17,000 (19,000)	15,000 (17,000)	31,000 (34,000)	28,000 (31,000)	55,000 (61,000)	31,106 (34,296)	62,213 (68,592)	37,000 (41,000)	73,000 (81,000)	43,000 (47,000)	84,000 (93,000)
Specialty Products Manufacturing	66,000 (73,000)	66,000 (73,000)	81,000 (89,000)	81,000 (89,000)	97,000 (107,000)	97,000 (107,000)	118,332 (130,465)	118,332 (130,465)	135,000 (149,000)	135,000 (149,000)	154,000 (170,000)	154,000 (170,000)
TOTAL Solid Waste To Disposal	9,769,000 (10,771,000)	10,205,000 (11,252,000)	12,275,000 (13,535,000)	13,205,000 (14,560,000)	13,257,000 (14,616,000)	14,747,000 (16,259,000)	1[illegible],328,801 (1[illegible],798,013)	16,170,067 (17,828,077)	17,507,000 (19,303,000)	20,350,000 (22,440,000)	18,644,000 (20,556,000)	22,473,000 (24,778,000)

TABLE 23

NATIONAL SOLID WASTE QUANTITIES TO DISPOSAL*

Year	Minimum	Maximum
1958	349 (698)	365 (730)
1963	345 (690)	371 (742)
1967	311 (622)	346 (692)
1971	287 (574)	324 (647)
1975	288 (576)	335 (670)
1980	254 (508)	306 (612)

*From Gorham International Inc.

All Weight Expressed In Kilogram Per Metric Ton Of Production
(Lbs Per Ton Of Production)

CHAPTER VII

SOLID WASTE MANAGEMENT ECONOMICS

The pulp and paper industry's costs to manage solid waste have never been determined on an overall basis. Various segments have been investigated, but many costs are simply accepted by the industry with no real knowledge of their absolute amounts. Often the costs are fragmented and are absorbed by various mill functions with no connection to the waste management system. For example, the solid waste management costs associated with ash from the boilers may be hidden within the operating budget for the power plant. While this practice is not wrong, it does lead to a lack of knowledge relative to overall solid waste management costs.

Based on case study data, supplier's data, and available literature, the total solid waste management costs per ton of solid waste material handled have been estimated for the industry's total solid waste management effort (Table 24). The unit costs for collection, processing, and disposal vary from mill to mill depending upon specific solid waste volumes, practices, characteristics, etc., but the presented averages for the industry are representative of total operations. Considering all labor and equipment inputs, the 1971 solid waste management cost approximated $4.26 per metric ton ($3.86 per ton) of solid waste transported to disposal.

This total cost estimate is based on standard cost development considering all phases of the solid waste management operations. While being higher than costs previously estimated for the pulp and paper industry solid waste management activities, this cost is economical compared to residential systems and to systems utilized by most other major industries. The 1971 annual cost (Table 25) indicates this industry's total expenditure for solid waste management activities.

TABLE 24

AVERAGE SOLID WASTE MANAGEMENT COSTS*

	Average Cost			
Solid Waste Activity	$/Ton		$/Metric Ton	
Internal Collection				
Labor	$0.75		$0.83	
Equipment	0.08		0.09	
Subtotal		$0.83		$0.92
External Collection				
Labor	$1.16		$1.28	
Equipment	1.57		1.73	
Subtotal		2.73		3.01
Disposal				
Labor	$0.14		$0.15	
Equipment	0.16		0.18	
Subtotal		0.30		0.33
TOTAL		$3.86		$4.26

*From Case Study Data and Gorham International Inc.

TABLE 25

SOLID WASTE MANAGEMENT COSTS - 1971*

	Regions					
	Northeast		North Central		South Atlantic	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Internal Collection						
Labor	$1,485,000	$1,642,000	$ 2,372,000	$ 2,667,000	$ 3,382,000	$ 3,810,000
Equipment	158,000	175,000	253,000	285,000	361,000	406,000
Subtotal	$1,643,000	$1,817,000	$ 2,625,000	$ 2,952,000	$ 3,743,000	$ 4,216,000
External Collection						
Labor	$2,297,000	$2,539,000	$ 3,669,000	$ 4,126,000	$ 5,230,000	$ 5,893,000
Equipment	3,108,000	3,437,000	4,966,000	5,584,000	7,079,000	7,975,000
Subtotal	$5,405,000	$5,976,000	$ 8,635,000	$ 9,710,000	$12,309,000	$13,868,000
Disposal	$ 277,000	$ 306,000	$ 443,000	$ 498,000	$ 631,000	$ 711,000
	317,000	350,000	506,000	569,000	721,000	813,000
Subtotal	$ 594,000	$ 656,000	$ 949,000	$ 1,067,000	$ 1,352,000	$ 1,524,000
TOTAL	$7,642,000	$8,449,000	$12,209,000	$13,729,000	$17,404,000	$19,608,000

(Continued On Next Page)

TABLE 25
(Continued)

	Regions					
	South Central		West		National	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Internal Collection						
Labor	$ 3,920,000	$ 4,251,000	$ 689,000	$1,001,000	$11,848,000	$13,371,000
Equipment	418,000	453,000	74,000	107,000	1,264,000	1,426,000
Subtotal	$ 4,338,000	$ 4,704,000	$ 763,000	$1,108,000	$13,112,000	$14,797,000
External Collection						
Labor	$ 6,064,000	$ 6,575,000	$1,066,000	$1,548,000	$18,326,000	$20,681,000
Equipment	8,207,000	8,899,000	1,443,000	2,095,000	24,803,000	27,990,000
Subtotal	$14,271,000	$15,474,000	$2,509,000	$3,643,000	$43,129,000	$48,671,000
Disposal						
Labor	$ 732,000	$ 794,000	$ 129,000	$ 187,000	$ 2,212,000	$ 2,496,000
Equipment	836,000	907,000	147,000	214,000	2,527,000	2,853,000
Subtotal	$ 1,568,000	$ 1,701,000	$ 276,000	$ 401,000	$ 4,739,000	$ 5,349,000
TOTAL	$20,177,000	$21,879,000	$3,548,000	$5,152,000	$60,980,000	$68,817,000

*From Case Study Data and Gorham International Inc.

This comparatively low cost structure results from a small number of generation points with high generation rates. These concentrated generation points lead to minimal internal collection activity except for janitorial type labor to transport solid waste to outside collection points. While external collection costs benefit from concentrated generation, this activity accounts for about 70 percent of the industry's total solid waste management costs. Again, this is not a wide variation from the rule of thumb indicating that 80 percent of all solid waste management costs result from collection activities. In fact, when internal collection is included, the total collection activity is about 90 percent of the industry's total costs.

Disposal costs represent only a small percentage of total cost (about 8 percent). This is reflected in the general condition of the industry's disposal sites that require substantial improvement to qualify as sanitary landfills.

Another method of assessing the industry's total solid waste management costs is relative to total production. On this basis each metric ton of final product represented a solid waste management cost of from $1.22 to $1.38 ($1.11 to $1.25 per ton) in 1971.

Resource Recovery Economics

In addition to the material handled as solid waste in the pulp and paper industry, considerable effort is expended to recover some value from materials that have served their primary function or have been separated from usable raw materials. The major sources of material from which some value is recovered are bark, salvageable metals, and off-specification product that is returned to the process stream.

The combustion of bark for its energy value represents both a volume reduction process to reduce solid waste quantities and a resource recovery operation to utilize the bark's energy value. The total bark consumed for energy purposes in 1971 was 9,648,122 wet metric tons (10,637,900 wet tons). The total salvageable metals sold to secondary materials dealers from pulp and paper industry operations is difficult to estimate because of fluctuations in equipment modifications, structural replacements, and other demolition type activities that generate salvageable materials.

Some sources such as machine shops, refiner plates, etc. are generated quite constantly, but details can at best be only a rough estimate based on case study data. From this source, we estimate that 91,165 metric tons (100,510 tons) of material were salvaged in 1971. The value of this material is equally difficult to estimate because of the mixture of metals reclaimed plus the regional and time variations in unit prices on the secondary materials market. The amount of fiber returned to the process stream represents another area with little quantitative data available. All broke generated on-machine is normally fed directly to pulpers that then recombine with the incoming stock stream. This flow of materials fluctuates drastically depending on operational problems, startups, etc. However, the industry uses an average of 10 to 20 percent recycled broke in the paper machine furnish.

Assigning economic values to these recovered materials is at best an approximation since the standard cost accounting systems used in the industry do not normally provide accessible information relative to these cost categories. Also, each mill's internal system and unit costs vary substantially thus providing different total values for resource recovery activities. Thus, the economics of these areas will be examined by citing hypothetical examples and then expanding these to estimate total industry cost and savings related to these resource recovery activities.

Bark Combustion. The use of bark as a fuel source has been previously described as a prevalent industry solid waste volume reduction and energy recovery process. Assuming that a pulp and paper mill is going to produce its own steam and electrical power, the incremental cost associated with bark burning is the cost of preparing the bark to be fed to the boiler and the cost of the material handling equipment. This normally includes size reduction equipment plus conveying, storage, and feeding equipment. Three 1972 examples (Table 27) indicate the economics associated with providing bark burning capabilities at large pulp and paper mill complexes. The annual depreciation cost has been based on straight line depreciation for a 20-year life. With the maintenance required to keep the size reduction equipment and conveyance system operating, a yearly maintenance expense equal to ten percent of the total capital cost has been assumed. The labor cost for these systems have been considered negligible because of their nearly automatic operation. Primary labor is provided by woodroom and boiler crews that would be required regardless of the fuel

TABLE 26

MILL DATA FOR BARK COMBUSTION EXAMPLES*

	Regional Location		
	South Central Mill A	South Atlantic Mill B	Northeast Mill C
Bark Consumption (Annual)			
Metric Tons	82,000	63,000	91,000
Tons	90,000	70,000	100,000

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*From Mill Industry Representatives

TABLE 27

BARK COMBUSTION EXAMPLES*

	Mill A	Mill B	Mill C
Capital Cost	$625,000	$900,000	$1,200,000
Total	$625,000	$900,000	$1,200,000
Annual Cost			
Depreciation (20 yr straight-line)	$ 31,250	$ 45,000	$ 60,000
Maintenance (10% of capital)	62,500	90,000	120,000
Total	$ 93,750	$135,000	$ 180,000
Annual Cost Credits			
Solid Waste Management Credit	$337,000	$262,000	$ 374,000
Other Fuel Cost Credit	234,000	182,000	260,000
Total	$571,000	$444,000	$ 634,000
Annual Savings (Total Credits Minus Total Annual Cost)	$477,250	$309,000	$ 454,000
Unit Savings			
Per Metric Ton Of Bark Consumed	$5.82	$4.90	$4.99
Per Ton Of Bark Consumed	$5.30	$4.41	$4.54

*From Gorham International and Industry Representatives source and cannot be considered incremental costs. Also, maintenance labor for greasing, oiling, repairs, etc. is considered to be part of the maintenance cost. Thus, the total annual incremental cost has been assumed to equal depreciation plus maintenance for the bark preparation, handling, storage, and feeding equipment. To offset the expense of processing the bark as a fuel, a cost saving results from not having to dispose of the bark waste as solid waste. Using the average industry cost per ton of solid waste to disposal and the difference between bark burned and bark ash to disposal, this annual cost savings was calculated.

An additional cost saving results from less primary fuel use to produce the power or steam consumed. Based on the BTU content, wet bark yields about 40 percent as much energy as does an equivalent weight of coal. Based on this assumption and a coal value of $7.17 per metric ton ($6.50 per ton) the fuel cost savings were calculated.

By applying the result of the above examples to the total bark consumed in 1971, a cost savings resulting from bark combustion (Table 28) was calculated. This analysis indicates the favorable economics associated with energy recovery from this solid waste source. Also, from the data presented, individual mills can determine (see Table 26 for mill data) how their bark combustion operation compares with these examples that represent relatively modern efficient facilities.

The 1971 industry saving from bark combustion was estimated in the neighborhood of 46 to 56 million dollars or approximately $1.00 per metric ton of total paper and paperboard production.

Secondary Materials Sales. The sale of secondary materials is predominantly scrap iron by weight, but due to high unit value such items as stainless steel, bronze, and other metals contribute significantly to total sales. With individual mill quantities varying substantially, five sample mills (representing 3% of industry production) were chosen to illustrate the variations that routinely occur in secondary materials sales even without sales resulting from large scale demolition or alteration projects (Table 29). By using this five mill sample as a basis for an industry projection, the total value for secondary materials sales is estimated to be $4,482,400 based on 85,260 metric tons (94,000 tons) of ferrous scrap and 5,905 metric tons (6,510 tons) of other scrap materials. This economic approximation was based on an average value of $20 per ton for ferrous scrap and $0.20 per pound for all other scrap material. These prices are subject to both local and time variations, but represent reasonable averages.

TABLE 28

BARK COMBUSTION ECONOMICS - 1971*

	Metric Ton Basis	Ton Basis
Bark Consumption	9,648,122	10,637,900
Savings - Minimum		
($/Unit Weight)	$4.87	$4.41
(Annual Total)	$46,900,000	$46,900,000
Savings - Maximum		
($/Unit Weight)	$5.85	$5.30
(Annual Total)	$56,400,000	$56,400,000

*From Gorham International Inc.

TABLE 29

SECONDARY MATERIALS SALES EXAMPLES - 1972*

	Category and Value							
	Ferrous Scrap			Other Scrap Materials			Annual Production Base	
Mill	Metric Tons	Tons	Estimated Value	Metric Tons	Tons	Estimated Value	Metric Tons	Tons
1	440	485	$ 9,700	27	30	$12,000	360,000	397,000
2	85	95	1,900	15	16	6,400	242,000	266,000
3	770	850	17,000	33	36	14,400	275,000	304,000
4	840	925	18,500	80	88	35,200	371,000	409,000
5	470	520	10,400	26	29	11,600	280,000	309,000
	2,605	2,875	$57,500	181	199	$79,600	1,528,000	1,685,000

*From Gorham International Inc. and Industry Sources

Based on total annual industry production, secondary materials sales account for a return to the mill of slightly less than ten cents per metric ton of total production. If some estimate of salvage by employees plus that from major renovations, equipment dismantlings, etc. could be made, the net return would probably increase to ten cents per metric ton of total production.

The cost associated with the material salvage program was estimated to equal the cost that would have been incurred to transport the same material to solid waste disposal sites. Thus, no credits or costs were assumed to be incurred by the salvage programs.

Fiber Reclamation. Fiber reclamation from the paper manufacturing operations represents an essential saving to the industry. Broke recovery systems are incorporated into nearly all production units and an average of 10 to 20 percent recycled broke is used in the paper machine furnishes. For illustrative and calculation purposes, a broke recovery rate equal to 15 percent of total production was chosen. The value of this recovered pulp varies within each mill depending on operational procedures, processes in use, accounting systems, and many other variables. However, for this analysis, the value was considered to be equal to market pulp to obtain a comparable base. Also, if this fiber source was removed, the additional input would have to be supplied from outside sources (market pulp) or by increased pulping capacity. An individual mill can determine internal broke recovery value by using their percent broke in the furnish and internal mill production costs per unit weight of pulp. The cost saving resulting from broke recovery (Table 30) results from the market value of the fiber recovered plus the solid waste management credit obtained from not having to collect and transport the material to disposal sites.

Because the capital cost of broke recovery is an integral portion of paper machine construction and capital cost, no cost segregation can be attempted. However, if no broke recovery was practiced, additional capital costs would be incurred to provide handling facilities for market pulp or additional on-site pulp mill production. Thus, it was assumed that regardless of fiber sources, capital costs would not result in any significant incremental costs for broke recovery systems. While many mills employ personnel to operate broke pulpers, many other mills have eliminated this labor cost by automating their broke recovery systems. Coupled with the fact that labor would be involved regardless of the fiber source, no incremental costs for broke recovery labor were included.

TABLE 30

FIBER RECOVERY ECONOMICS - 1971*

Total Salable Production	55,091,530	tons	49,968,017	metric tons
Total Recovered Broke	9,722,034	tons	8,817,885	metric tons
Total Machine Production	64,813,564	tons	58,785,902	metric tons
Total Fiber Recovered	9,722,035	tons	8,817,885	metric tons
1971 Value	x $130	per ton	x $143	per metric ton
Subtotal	$1,263,864,000		$1,260,958,000	
Solid Waste Disposal Credit	9,722,035	tons	8,817,885	metric tons
1971 Cost	x $3.86	per ton	x $4.26	per metric ton
Subtotal	37,527,000		37,564,000	
Total Fiber Recovery Savings	$1,301,391,000		$1,298,522,000	

*From Gorham International Inc.

This analysis assumes that actual sold production is equivalent to 85 percent of the total tonnage produced with the remainder returned to the paper machine furnish via the broke recovery systems.

The total cost savings of $1,301,391,000 represents an equivalent saving of $26.09 per metric ton ($23.62 per ton) of total paper and paperboard production. Based on these calculations, it is obvious why broke recovery is considered an integral and required operation in the papermaking field.

Resource Recovery Economics Summary. Cost savings from the pulp and paper industry's resource recovery activities routinely provide the companies with an improved overall economic picture. It is also evident that the industry has undertaken resource recovery activities that do not represent marginal economic projects.

With the current emphasis on improved environmental quality, fuel shortages and raw material utilization, it is expected that resource recovery activities will expand. Such an expansion also means that resource recovery alternatives with lesser economic returns will be considered feasible because of their favorable impact on other effluent treatment processes and on the industry's and the firm's public image.

CHAPTER VIII

ENVIRONMENTAL LEGISLATION IMPACT ON SOLID WASTE MANAGEMENT

Solid waste management practices in the pulp and paper industry, as well as in other industrial and public sectors, have to date been the least influenced by the past few years' increased emphasis on environmental control. However, actual solid waste management legislation plus the actions taken to satisfy air and water pollution control legislation are having an increasing effect on solid waste management activities. This chapter will briefly summarize the trends in environmental legislation and then present the possible impact of these trends on the pulp and paper industries' solid waste management practices.

Present Legislation and Trends

Federal Legislation. Current federal legislation with potential for a significant impact on solid waste management centers on air and water legislation. No actual regulatory legislation exists for solid waste as a separate pollution source.

Federal water legislation had its start with the River and Harbor Act of 1886 that was modified to become the now famous River and Harbor Act of 1899. Significant water legislation was not enacted again until 1948 when the original Federal Water Pollution Control Act was passed. Since that time the following legislation has expanded federal water pollution activity and established the program as it now exists:

Water Pollution Control Act Amendment of 1956

Water Quality Act of 1965

Clean Water Restoration Act of 1966

Water Quality Improvement Act of 1970

Federal Water Pollution Control Act Amendment of 1972

The 1972 amendments basically set the thrust of water pollution control efforts to limiting the amount of pollutants that can be discharged from specific point sources. The current schedule calls for EPA to publish regulations to identify the best practicable control technology for the pulp and paper industry as an industrial category (issuance is currently in progress). All mills must meet these regulations by July 1, 1977. Also, EPA shall identify the best available technology for preventing and reducing pollution. Responsibility includes identifying technology that would achieve the elimination of pollutant discharges. Standards resulting from the above activities must be met by industrial plants by July 1, 1983. The zero discharge goal of 1985 is a goal and is not required under the law. The result of the above investigations will determine to what degree various pollution sources must approach zero discharge.

In addition to establishing effluent limitations and acceptable technology, EPA has ultimate responsibility for the water quality standards, effluent discharge permits, new source performance standards, ocean dumping activities, and control of toxic pollutants. Effluent discharge permit programs are being administered by the EPA regional offices. These permits are required for all point sources of discharge.

Overall, the federal water pollution program is now established to provide for increasingly stringent effluent limitations and improved national water quality. Little additional legislation is foreseen unless basic philosophies change or specific segments of the current law prove unworkable.

The principal impact on the industry's solid waste management will be the problems associated with properly managing the solid material that must be removed from the liquid effluent. While leachates do not generally qualify as a point source, they will undoubtedly receive additional attention as other liquid effluents become better controlled and less of a pollution problem.

Air pollution efforts on the federal level began with the Air Pollution Act of 1955. The following legislation has expanded activity to its present level:

Motor Vehicle Pollution Control Act of 1965

Air Quality Act of 1967

Clean Air Act of 1970

The 1970 legislation authorized national, uniform quality standards based on geographical regions. Primary standards are set at levels to prevent people from experiencing illness. Secondary standards are designed to protect public welfare and to prevent damage to animals, plants, and property. To achieve these standards, EPA has approval authority over state established implementation plans and their enforcement.

Additionally, EPA has authority to control new stationary sources of air pollution and hazardous air pollutants plus automobile emission standards and specific enforcement activities. Basically, federal legislation is designed to provide a framework for state control activity. Future legislative activity is foreseen to amplify unclear areas of the present legislation and to extend program activity.

Primary impact on pulp and paper industry solid waste management programs will be how to manage the additional pollutants removed as solid waste.

Federal solid waste management activity commenced with the enactment of the Solid Waste Disposal Act of 1965. That original legislation was amended in the Amendment of 1968 and by the Resource Recovery Act of 1970. Besides research, demonstrations, and technical assistance, EPA's solid waste program publishes guidelines for solid waste recovery, collection, separation, and disposal systems. The guidelines will serve as recommendations to state and local governments. Unlike air and water legislation, solid waste management legislation provides no overseeing of state programs by federal officials.

Current emphasis at the federal level is on proper management techniques for hazardous and toxic solid waste. Future legislation is expected to expand program emphasis in areas such as hazardous materials, resource recovery, collection, processing, etc.

With present and proposed legislation, the paper industry should feel no direct impact from the federal level except for any possibly hazardous or toxic solid waste. With no readily identifiable quantities of toxic or hazardous materials, no management problems are foreseen in this area. Thus, the principal impact of hazardous waste legislation will be making appropriate filings and providing required background data to satisfy regulatory requirements. Indirect impact will come from state and local authorities who may be following recommended EPA guidelines.

Federal legislation as presently enacted and as expected for the future will require that increasing pollutant quantities be removed from liquid and gaseous effluent streams. This, coupled with requirements for improved solid waste disposal site operations to satisfy air and water pollution limitations, presents the major impact on the industry's solid waste management practices.

State and Local Legislation. Legislation at the state and local level is designed primarily to meet federal guidelines and to provide specific requirements that must be met by effluent discharges within each state.

Water pollution legislation as applied to the pulp and paper industry is taking the form of establishing effluent limitations based on federal guidelines. New recommended levels are currently being published by EPA. While some states may impose effluent limitations more restrictive than the guidelines, the tendency is to accept guideline levels. This results in nearly standard required effluent discharge requirements throughout the nation. Most states are also involved in effluent discharge permit programs. Local legislation with impact on the industry is negligible. Local legislation is designed to facilitate proper installation and operation of sewer lines, joint treatment plants, etc. and does not generally establish specific discharge levels. The 1972 federal effluent limitation guidelines have been the basic industry standards, but are being modified by the new best practicable treatment guidelines (Tables 31 & 32). Effluent limitations for the 1983 and 1985 deadlines cannot be estimated at this time, but process changes, internal water reuse, and external treatment will most likely be required to meet more stringent standards.

Air pollution legislation at the state level is designed to provide ambient air quality capable of meeting EPA established ambient standards. The primary standards that apply to the pulp and paper industry are those limiting generation of sulfur compounds. Regulations limiting both sulfur dioxide (SO_2) and total reduced sulfur compounds (TRS) may require additional material to be removed from the industry's gaseous effluents. However, the TRS limitations result primarily from chemical recovery operations associated with chemical pulp mills, and any

TABLE 31

RECOMMENDED EFFLUENT LIMITATIONS FOR THE PULP AND PAPER INDUSTRY*

Production Process	Kg/Metric Ton Of Product	Lb/Ton Of Product	Kg/Metric Ton Of Product	Lb/Ton Of Product
Kraft Pulping And The Manufacture Of:				
Coarse Paper and Linerboard	2.5	5.0	2.5	5.0
Newsprint	2.5	5.0	3.0	6.0
Bleached and Unbleached Grades	4.5	9.0	5.0	10.0
Bleached Grades	5.5	11.0	5.0	10.0
Sulfite Pulping And The Manufacture Of:				
Paper	17.5	35.0	10.0	20.0
Dissolving Pulp	30.0	60.0	10.0	20.0
Neutral Sulfite Semi-Chemical:	7.0	14.0	4.0	8.0
Groundwood:				
Unbleached	1.3	2.5	25.0	5.0
Bleached	2.3	4.5	4.5	9.0
Deinking Mill:	5.0	10.0	6.0	12.0
Paperboard (No Deinking):	1.5	3.0	1.5	3.0
Paper Manufacture (From Purchased Pulp):				
Coarse	1.0	2.0	1.5	3.0
Fine (<8% Filled)	3.0	6.0	3.5	7.0
Book (>8% Filled)	1.5	3.0	2.0	4.0
Tissue	4.0	8.0	3.0	6.0

*From Environmental Protection Agency, June, 1972

TABLE 32

BEST PRACTICABLE TREATMENT GUIDELINES FOR THE PULP AND PAPER INDUSTRY*

Industry Sector	BOD Maximum 30 Day Average Kg/Metric Ton Of Product	 Lb/Ton Of Product	Suspended Solids Maximum 30 Day Average Kg/Metric Ton Of Product	 Lb/Ton Of Product
Unbleached Kraft	2.2	4.4	4.6	9.2
Sodium Base Neutral Sulfite Semi-Chemical	3.25	6.5	5.0	10.0
Ammonia Base Neutral Sulfite Semi-Chemical	5.25	10.5	5.0	10.0
Unbleached Kraft-Neutral Sulfite Semi-Chemical (Cross Recovery)	3.05	6.1	5.3	10.6
Paperboard From Wastepaper	1.25	2.5	1.5	3.0
Builders' Paper And Roofing Felt	2.5	5.0	2.5	5.0

*From EPA and Federal Register - All Guidelines Issued Through February 1, 1974 material recovered from the pulping area and recovery stacks will be returned to the recovery process for combustion in the recovery boiler. Thus, increased solid waste generation is unlikely to result from increased air pollution controls on chemical pulping and recovery operations. However, SO_2 and particulate regulations applied to power and steam generating facilities will have an impact on the pulp and paper industry. These regulations vary locally depending on what discharge levels are allowable while maintaining federal ambient standards. Two types of regulations are commonly used for SO_2. First, the allowable percentage of sulfur in the fuel supply is used to control sulfur input. Second, the allowable pounds of SO_2 per million Btu's is used as an effluent standard. Actual local regulations are generally limited to the outlawing of open burning and do not apply to effluent discharges which are left to the state authorities.

Solid waste management legislation is a combination of state and local regulations depending on specific governmental structures, customs, etc.

In response to individual letters sent to state solid waste management agencies, 19 responded explaining their industrial solid waste management programs in varying degrees of detail. Of the 19 respondents, 14 indicated that state legislation and/or rules and regulations are currently effective (mid-1973). The actual degree of enforcement was not indicated in most cases, but from general comments it was concluded that approximately one-half (7) were actively issuing permits and monitoring sites while the other half (7) were still involved in developing an active program for implementation. Two other states stated that they were conducting surveys and proposing legislation while three respondents did not mention their legislative or regulatory status.

The state solid waste agencies responding were tending toward requiring operating permits for all solid waste disposal sites with permit issuance based primarily on site operational characteristics. In areas with strong county government the county officials may retain responsibility for issuing permits to maintain proper solid waste disposal site operations. Also, local regulations may impose restrictions on solid waste storage or transportation particularly as related to public nuisances and health oriented problems.

Overall, state and local legislation appears designed to meet federally established goals, to satisfy federal recommendations, and to prevent state and local nuisance conditions. Based on our sample response and overall environmental concern, state and local legislation is expected to require licensing and monitoring of nearly all industrial solid waste disposal sites by 1980.

Legislative Impact On Solid Waste Categories

The impact of environmental legislation on the pulp and paper industry's solid waste generation will be most directly felt by the additional material that will require handling in the solid waste systems. Actual solid waste characteristics will be affected as additional classes of pollutants require removal from the air and water. For example, color removal processes for kraft mill effluents may generate sludges that will be different from normal primary and secondary wastewater treatment plant sludge. Possibly the most significant new solid wastes will be those resulting from air pollution systems designed to remove sulfur oxides from power plant gases.

Wastewater Treatment Solid Waste. For established environmental legislation programs, the effect on solid waste management quantities was considered when future solid waste generation quantities were projected (Chapter VI). Both primary and secondary wastewater treatment sludge will show a continual rise through 1980. This increase will result primarily from increasing production and from the application of increasingly stringent effluent limitations. Suspended solids in the industry's effluent were approximately 23 kilograms per metric ton (46 lb per ton) of production in 1971. Estimates for 1980 based on tentative effluent limitations indicate that total industry effluent will average approximately 5 kilograms per metric ton (10 lb per ton) of production. This expected effluent discharge reduction will increase the wet sludge entering the solid waste management systems (@ 33% solids) for disposal by 2.2 to 3.4 million metric tons (2.4 to 3.7 million tons). Actual performance will depend upon what process modifications and internal measures are taken to reduce effluent losses as well as what effluent treatment advances are implemented. As effluent discharges are reduced, the quantity of solid material removed from the effluent stream becomes an increasing problem. Strict legislation will force private efforts designed to maximize raw material usage while decreasing effluent discharges. The primary sludge characteristics will change because smaller particles will be removed from the wastewater. Also, with better internal fiber retention, sludge fiber content will decrease.

Industry BOD_5 discharges are expected to decrease from the 1971 level of 27 kilograms per metric ton (54 lb per ton) of capacity to 3 kilograms per metric ton (6 lb per ton) of production in 1980. Based on estimated disposal practices, this will result in an additional 1.2 to 2.1 million metric tons (1.3 to 2.3 million tons) of wet sludge requiring disposal via the industry's solid waste management systems. This amount is assuming that the secondary sludge is dewatered with primary sludge and reaches a 33 percent solids level. It is expected that some installations will achieve a lower solids content thus requiring that more water be transported to disposal.

Application of more stringent environmental restrictions (groundwater contamination, flooding danger, effluent restrictions, etc.) will increase the cost of sludge lagooning, thus increasing the economic feasibility of dewatering system installations.

Wood Yard Solid Waste. The only significant impact on wood yard solid wastes will be an increased pressure to increase utilization of bark wastes for fuel or other uses. Land disposal of these organic solid wastes can lead to leachate problems while reuse provides an economic advantage that acts as an incentive to undertake bark recovery projects. Additionally, bark and wood wastes are low in sulfur and may be used to lessen sulfur compound emissions from steam and power boilers. Thus, environmental regulations are one of the forces pushing for increased utilization of wood yard solid waste.

Air Pollution Control Solid Waste. Solid waste from air pollution control equipment is currently represented by the ash resulting primarily from coal and bark combustion. Most industry power and steam generation units are equipped with particulate collection equipment. Dry and wet collection systems are used to collect both the bottom ash and the flyash for land disposal. The total particulate values for the industry's coal usage were considered in establishing the national generation trends.

Removal of sulfur oxides resulting from sulfur containing fuels is an area currently open to much conjecture. Even at federal hearings to assess air pollution timetables, the availability of technology to meet sulfur oxide standards was subject to much conflicting testimony. The final resolution satisfactory to all parties could not be achieved even with major inputs from many participants. Currently, if all pulp and paper industry power plants can obtain low sulfur fuels to meet sulfur oxide limitations no increase in solid waste from desulfurization systems will result. However, the final report of the Sulfur Oxide Control Technology Assessment Panel (SOCTAP) predicts a shortage of low sulfur fuel by 1975(14).

Realistically, the pulp and paper industry's commitment to sulfur oxide removal from stack gases appears to be a long term concern. Current priority for sulfur oxide control is being given to the power generating industry rather than to smaller private industry power plants. However, several factors appear to limit the expansion of flue gas desulfurization practices even in the power utility industry. The availability of professional manpower to engineer and design such systems is limited. The utility companies have essentially no chemical process industry talent to apply to this problem while vendors and engineering consultants have only limited numbers of people trained for such efforts. Also, skilled construction personnel are in increasing demand for other environmental control projects (domestic and industrial wastewater treatment facilities) and will be the limiting factor for construction projects in many areas throughout the 70's. Coupled with all these factors, the manufacturers of flue gas desulfurization equipment have limited production capacity and are not expected to be able to expand rapidly enough to satisfy the power utility companies if full scale flue gas desulfurization is undertaken. Thus, the possibility of finding qualified suppliers for the small pulp and paper industry power boilers becomes remote at best. Also, the largest pulp and paper industry complexes are located in nonurban areas that have a lesser sulfur oxide pollution problem than many high density urban areas. Thus, if insurmountable circumstances delay installation of flue gas desulfurization technology, this industry would be a likely candidate for temporary relaxed implementation schedules.

At the present time, four basic flue gas desulfurization technologies can be considered for full scale use within the next five years. First, wet lime/limestone systems involve scrubbing with limestone or lime slurries. Several specific processes are of this basic type and employ different feeding and cycle techniques to achieve desulfurization. These approaches normally generate large amounts of $CaSO_3$ and $CaSO_4$ sludges that require ponding or dewatering for land disposal. Second, magnesium oxide scrubbing is much like lime scrubbing except that spent salts are regenerated to produce a stream of 15-20 percent SO_2 for sulfuric acid manufacture and magnesium oxide for reuse. A necessary precaution is that high flyash removal levels must be maintained prior to magnesium oxide scrubbing to protect the recycle stream from flyash contamination. Third, a modified version of the contact H_2SO_4 process operates by passing the flue gas through a fixed catalyst bed where SO_2 is converted to SO_3 that is absorbed in recirculated H_2SO_4 in an absorption tower. This process also requires high particulate removal efficiency to prevent plugging of the catalyst bed. Fourth, sodium base scrubbing is used with regeneration. The gas is absorbed into a combination sodium sulfite, bisulfite, and sulfate. The system is subject to contaminants and requires a bleed line to maintain system balance. Final products can be processed to liquid SO_2, sulfur, or sulfuric acid. Many other techniques are in various stages of development (total exceeds 50) and some will undoubtedly proceed to commercial usage. Sludge from these processes will require careful disposal procedures to prevent the leaching of chemical components to ground or surface water supplies. While the compounds present are not hazardous materials, changes in acidity plus excessive nutrient enrichment can cause localized pollution problems. Disposal will require that the site be designed to prevent leachate contamination of nearby waters. Also, land areas receiving large quantities of this semisolid sludge will have essentially no value for future uses unless a program of intermediate and final cover or of soil and sludge mixing is practiced.

Based on the current uncertainty in the entire flue gas desulfurization area, the potential solid waste volumes are difficult to determine. Also, with the many potentially applicable technologies, no degree of certainty can be established relative to the technologies that may be most economical in commercial use. To indicate the potential magnitude of the desulfurization process solid waste, the recent SOCTAP report presented the comparative quantities of ash and potential sulfur products from coal fired boilers controlled with flue gas desulfurization systems. These calculations indicate the potential solid waste generation from the most developed desulfurization systems currently available. Also indicated is the quantity of possible saleable product that could be a disposal problem if insufficient market demand exists to use available by-product supplies. If this information is applied to only the pulp and paper industry's coal burning operations, a large new additional solid waste source rapidly develops (Table 33) This estimate indicates the potential order of magnitude for this type solid waste resulting from air pollution control and fuel supply requirements.

While it is expected that flue gas desulfurization will be demonstrated before 1980 in the pulp and paper industry, it is doubtful that significant solid waste from such processes will be generated by that time. However, it does remain a serious potential solid waste situation and merits attention, both from solid waste management and potential resource recovery aspects.

From chemical recovery process operations, most material collected by air pollution control equipment can be either introduced into the recovery furnaces or elsewhere in the chemical recovery system. This includes both particulates and the odorous compounds. Generally the mercaptans, hydrogen sulfide, and other odorous gases are introduced to the lime kiln or a separate burner for complete combustion. Alternately, sulfur compounds can be stabilized so they will stay in the recovery cycle and not be discharged to the atmosphere. New mills use noncontact evaporators that eliminate contact between the liquor and flue gas. Based on the current approaches to recovery system air pollution abatement, increased solid waste from this source will not represent a management problem. The only impact will be improved chemical utilization as air losses are decreased via improved gaseous effluent treatment.

All Other Solid Waste Categories. The other solid waste categories will be affected only indirectly and to lesser degrees by environmental legislation. The solid waste generation ranges previously presented will not show significant changes through 1980.

The only changes that will result will be those caused by a slow general shift in overall corporate attitudes toward more efficient raw materials utilization and recovery. For example, the solid waste associated with residuals handling will become a

TABLE 33

ESTIMATED QUANTITIES OF ASH AND SULFUR PRODUCTS FOR PULP AND PAPER INDUSTRY COAL FIRED BOILERS IF EQUIPPED WITH FLUE GAS DESULFURIZATION SYSTEMS*

	Yearly Production Metric Tons/Yr (Tons/Yr)	Approximate Storage Volume For 20 Yrs Hectare/Meters (Acre/Ft)
Coal Ash, Dry	1,533,000 (1,690,000)	2,040 (16,500)
Limestone Sludge, Dry		
50% $CaSO_3$ 1 H_2O	1,460,300 (1,610,000)	6,990 (56,600)
9% $CaSO_4$ 2 H_2O	215,400 (237,500)	
33% $CaCO_3$ Unreacted	839,000 (925,000)	
Total	2,514,700 (2,772,500)	
Lime Sludge, Dry		
76% $CaSO_3$ ¼ H_2O	1,460,300 (1,610,000)	5,360 (43,400)
12% $CaSO_x$ 2 H_2O	213,200 (235,100)	
12% CaO $(Ca(OH)_2$	235,800 (260,000)	
Total	1,909,300 (2,105,100)	
Sulfur		
(90% Overall Recovery)	403,600 (445,000)	390 (3,150)
Sulfuric Acid		
(95%)	1,258,500 (1,387,500)	1,430 (11,600)

(Continued On Next Page)

TABLE 33
(Continued)

Assumptions:

Coal - 3.5% Sulfur; 12% Ash; 2,816,000 Tons Coal/Yr For 1,000 MWe Capacity; Coal Usage 0.88 Lbs/ Kwh; Production Time - 6,400 Hrs/Yr

Total MWe - 1971 Pulp & Paper Industry Coal Consumption = 14,265,000 Ton; 14,265,000 Tons Coal/ 2,816,000 Tons Coal/MWe = 5 MWe Equivalents

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*Based On Calculations From Sulfur Oxide Control Technology Assessment Panel's Final Report larger quantity because of increased wood residuals usage. As this total quantity grows, the industry may well undertake activities aimed toward recovering this fiber loss. Similarly, losses in other production areas will be investigated to determine if either primary or secondary uses are feasible alternatives to disposal.

Legislative Impact On Solid Waste Management Systems

The increased emphasis on environmental activities and resulting changes in solid waste generation will have definite effects on the pulp and paper industry's solid waste management systems.

Impact on Technology. The solid waste management technology currently utilized in the pulp and paper industry is basically the same as that used in municipal and commercial solid waste management activities. While techniques vary to satisfy specific requirements, very little proprietary or unique solid waste technology is practiced within the industry. Except for additional resource recovery practices, there seems to be little predictable alteration from this pattern in the future.

Future environmental legislation is not foreseen to have any effect upon collection and storage practices internal to the industry's mills. The primary concerns will be good housekeeping practices and protecting against inadvertent spillage of solid waste materials into liquid effluent drains or other areas that could lead to environmental degradation. Outside storage and collection practices will be affected principally in areas where solid waste quantities are increased. These areas tend to be point sources (wastewater treatment plants, boilers, etc.) and the application of more efficient materials handling equipment will be the primary improvement to ease collection and storage difficulties.

Areas that generate general trash and paper wastes (offices, storerooms, warehouses, etc.) will tend to increase the use of stationary compaction equipment to reduce bulkiness and collection frequency. This approach will enable the existing collection equipment to handle increased solid waste quantities with existing manpower.

As solid waste quantities increase and the regulations governing disposal become stricter, increased solid waste processing will be introduced. The primary emphasis will be on methods to recover value from the solid waste while reducing the weight and volume to be handled. The increasing use of shredders and hog fuel boilers will be the principal expansion area. With most large solid waste sources consisting of materials that are largely combustible and recognizing the industry's power and steam demands, this trend will be the one explored in the greatest depth. Also, recovery of all possible fiber currently entering the waste stream will receive concentrated attention.

The area most affected by environmental legislation will be the industry's disposal sites. The present proliferation of open dumps will require extensive effort to meet state and local regulations currently in various forms of development. When sanitary landfill criteria are applied to industrial disposal sites, additional personnel and equipment plus design and planning will be required.

Sanitary landfill planning and design standards will eliminate many existing disposal sites because of groundwater considerations, high flood risks, soil requirements, lack of cover material, etc. Thus the impact of environmental legislation will act directly upon disposal site operations plus, in some cases, add to the hauling costs. These pressures will increase the attractiveness of previously marginal processing and resource recovery activities.

Overall, little new technology is foreseen except for possible novel resource recovery operations. Most improvements will result from applying available technology and improved management techniques.

Impact On Economics. The economic impact of environmental legislation will be concentrated in two different sources. First, the management of increasing sludge and sludge ash quantities will add collection and disposal costs. At 1971 rates, this additional annual solid waste management cost will range from $7.2 million to $12 million in 1975 and from $15 million to $23.9 million in 1980 (Table 34). Depending upon inflation rates, these costs could be higher at that time. Also, the industry will be expending proportionally more money to remove this material from the wastewater and to prepare it for the solid waste stream. Second, the cost of disposal operations will increase dramatically as regulations force industrial disposal sites to meet sanitary landfill criteria. It is expected that by 1980, nearly all this industry's solid waste disposal sites will be required to meet state criteria to obtain an operating permit.

TABLE 34

INCREASED SLUDGE HANDLING AND DISPOSAL COSTS*

	1975		1980	
	Minimum**	Maximum**	Minimum**	Maximum**
Primary Sludge				
Additional Quantity Over 1971				
Metric Tons	1,347,000	2,084,000	2,209,000	3,386,000
(Tons)	(1,485,000)	(2,298,000)	(2,435,000)	(3,733,000)
1971 Costs				
$/Metric Ton	$4.26	$4.26	$4.26	$4.26
($/Ton)	($3.86)	($3.86)	($3.86)	($3.86)
Additional Cost Over 1971 @ 1971 Rate	$5,700,000	$ 8,900,000	$ 9,400,000	$14,400,000
Sludge Ash				
Additional Quantity Over 1971				
Metric Tons	32,000	52,000	92,000	149,000
(Tons)	(35,000)	(57,000)	(101,000)	(184,000)
1971 Costs				
$/Metric Ton	$4.26	$4.26	$4.26	$4.26
($/Ton)	($3.86)	($3.86)	($3.86)	($3.86)
Additional Cost Over 1971 @ 1971 Rate	$ 100,000	$ 200,000	$ 400,000	$ 600,000

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TABLE 34
(Continued)

	Secondary Sludge			
	1975		1980	
	Minimum**	Maximum**	Minimum**	Maximum**
Additional Quantity Over 1971				
Metric Tons	327,000	691,000	1,214,000	2,088,000
(Tons)	(360,000)	(762,000)	(1,339,000)	(2,302,000)
1971 Cost				
$/Metric Ton	$4.26	$4.26	$4.26	$4.26
($/Ton)	($3.86)	($3.86)	($3.86)	($3.86)
Total Additional Cost Over 1971 @ 1971 Rate	$7,200,000	$12,000,000	$15,000,000	$23,900,000

*From Gorham International Inc.

**Ranges Result From Raw Waste Load Data - Use Average For Calculations

Disposal costs averaged about $0.33 per metric ton ($0.30 per ton) of solid waste in 1971. It is expected that by 1980, this cost will reach at least $1.65 per metric ton ($1.50 per ton). This will result in a total industry cost of from $26.1 million to $31.8 million greater than the total 1971 disposal cost (Table 35). An additional increase in transportation costs will result as disposal sites become more distant from the mill sites. These more remote disposal sites will result both from land shortages and from environmental restrictions on new disposal sites.

With increasing costs from several sources plus increased quantities in some solid waste categories, the pulp and paper industry will increase efforts to obtain at least some return from these solid waste materials. Emphasis will focus on recovery of materials for new by-products, internal use of raw materials, and reclamation of energy from combustible materials. Thus, the industry will be searching for currently unknown credits to offset increasing solid waste management costs, some of which result directly from environmental legislation.

TABLE 35

INCREASED DISPOSAL COSTS - 1980*

	1971		1980	
	Minimum	Maximum	Minimum	Maximum
Total Solid Waste Quantity To Disposal				
Metric Tons	14,329,000	16,170,000	18,644,000	22,473,000
Tons	15,798,000	17,828,000	20,556,000	24,778,000
Disposal Cost				
$/Metric Ton	$0.33	$0.33	$1.65	$1.65
$/Ton	0.30	0.30	1.50	1.50
Total Disposal Cost	$4,700,000	$5,300,000	$30,800,000	$37,100,000

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*From Gorham International Inc.

CHAPTER IX

TECHNOLOGY ASSESSMENT

The major solid waste management technology used by the pulp and paper industry does not include any sophisticated processes or methods that have resulted from specialty development efforts except for internal resource recovery. This entire disposal field has been treated as a "necessary evil" that must be handled to maintain operations and has not received major efforts aimed at improving the state of-the-art. Thus, the question of new advances or improvements has not been a concern and will not until management realizes that further cost saving (profit increasing) actions are possible in the solid waste management field.

The current technology and practices have been previously described (Chapter V) and will represent the base upon which future technology can be built. Potential improvements and alternatives for existing practices will be presented in this chapter.

Collection and Storage

Solid waste collection and storage in the pulp and paper industry is divided into activities internal to the mill buildings (equivalent to homeowners activities) and activities external to the mill buildings (equivalent to the public or private solid waste collection agency).

Activities internal to the mill result primarily from the smaller generation sources such as personnel activity and manufacturing services while most major sources are predominantly point sources that require either individual collection systems or mechanically handled containers.

Current internal activities usually employ janitorial type personnel to transport solid waste from individual small container locations to larger outside storage containers for pick up and transportation to disposal. The use of 208 liter (55 gallon drums) salvaged from mill operations plus the use of broke carts to transport solid waste often represents a false economy. Depending on mill layout, solid waste quantities, and labor rates, the use of a small compaction vehicle with an operator may be more economical than a crew of waste handlers working as manual laborers.

Several equipment alternatives exist to meet individual mill circumstances. If solid waste is already transported to stationary compactors, a scooter type vehicle with a dump hopper or with a train of containers may efficiently collect internal solid waste. Standard outside haul-away containers equipped with casters can be used for internal collection and placed on docks or in designated outside storage areas for pick up by a normal compaction vehicle. Other compactor collection units that can be used in relatively crowded areas include trailer compactors and pick-up mounted units that could be used either for transfer situations or for direct haul to disposal sites. Use of this type unit coupled with lighter and easier to handle solid waste containers can increase collection efficiency for small point waste sources both internal and external to the mill buildings. Based on solid waste volumes and scattered generation points, any type of automated collection (pneumatic or slurry) would normally be an uneconomical alternative.

Cost savings could also be realized by improved collection scheduling. Except for point sources having specific collection vehicles, most mill collection equipment simply patrols the mill property for collection points needing collection. Based on a background study to accurately define solid waste generation rates and collection requirements, routine collection schedules could be established to minimize collection labor and to allow maximum equipment utilization.

For areas with larger generation rates, the industry could take steps to increase the collection and storage efficiency. Presently the best collection and storage operations are associated with bark wastes that are to be combusted to recover the energy value. Automatic conveyor systems, pneumatic pipelines, and storage bins are used to provide a continual bark flow to the boilers. Gravity fuel hoppers have often been used for storage and feeding purposes, but the most successful systems now employ "Atlas" bins for bark storage and feed. These units are shaped like an inverted cone with stored material being removed by a chain of bucket conveyors drawn around the base of the stored material (see Figure 9, page 30). The buckets are pulled in a manner such that they continually follow the perimeter of the pile and provide a uniform feed rate to the boilers with minimum fluctuations. Increased usage of this system is becoming evident in the industry and usage will continue to rise as new bark handling systems are installed.

Pneumatic collection of sawdust from long log slashers has also been demonstrated in the pulp and paper industry and will find more applications as long log usage continues to increase. This material represents a good fuel and presents no problems in a bark burning system.

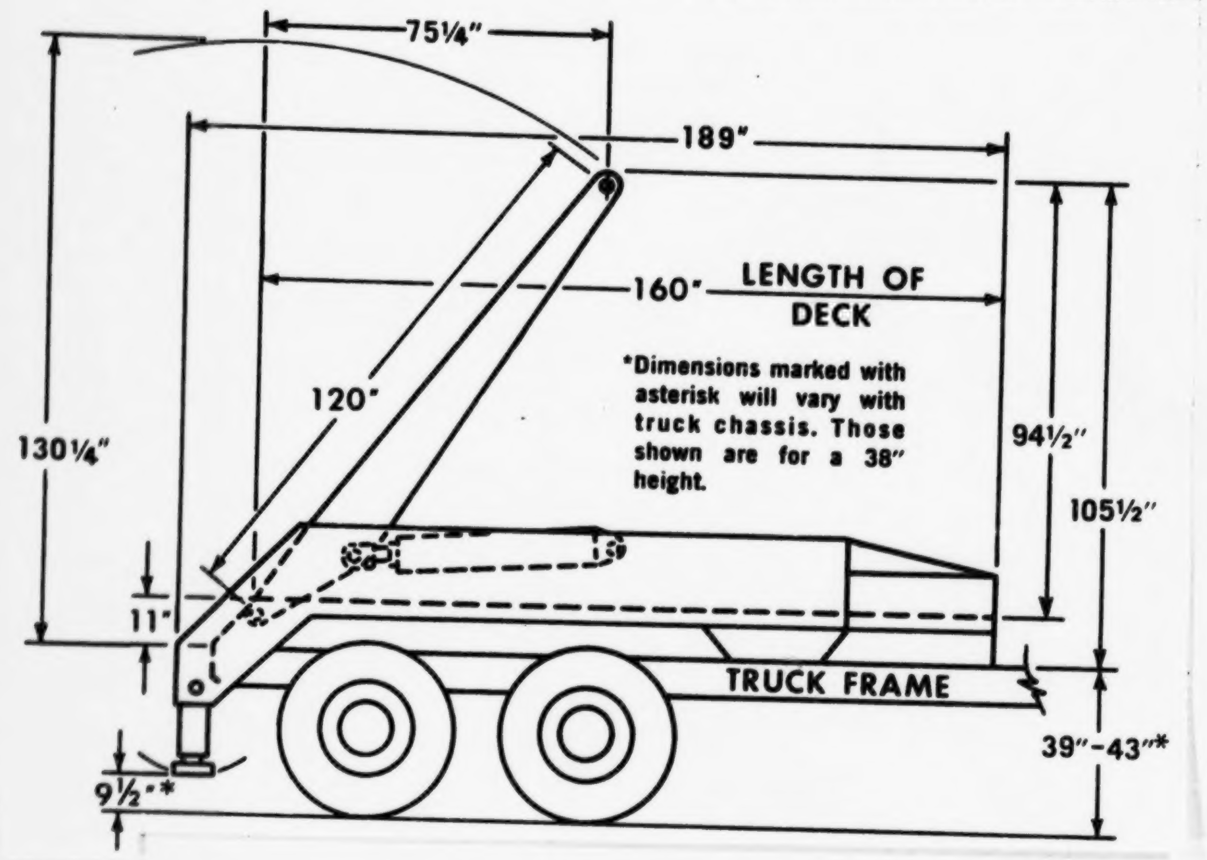
The use of separate collection vehicles for individual major solid waste sources is widely practiced in the pulp and paper industry. While in some instances this may be the most economical practice, the multi-purpose vehicle that can handle several types of large bulk containers would reduce total costs in many instances. Depending on actual solid waste quantities, haul distance, etc., one or more truck units can service several containers collecting one solid waste type or a variety of solid waste types. Also, containers can be obtained to handle liquids and other materials thereby making it a desirable vehicle for all mill operations. Converto, a division of Golay and Company manufactures a hoist system and containers of this type (Figures 9 & 10). Also, the large capacity roll-off roll-on and tilt frame units such as manufactured by Mid Equipment Inc., Dempster Brothers Inc., Heil, and other refuse equipment manufacturers can be used to collect multiple solid waste sources. Particularly for wastewater treatment plant sludges, boiler ash and chemical pulping solid wastes, the multiple container hauling units represent an available, but mainly unused equipment scheme for the pulp and paper industry. Additionally, the same unit can handle containers in use with stationary compactors for personnel, manufacturing services, and other compactable solid wastes.

The above container systems are not to be confused with the systems that the industry presently uses extensively. The present systems employ small containers (normally up to 7.6 cubic meters - 10 cubic yards) while the above units can employ up to 17 cubic meter (22 cubic yard) containers. The use of one driver servicing several containers provides cost savings in both equipment and labor categories plus providing more extensive equipment capabilities for all material handling operations.

Solid waste generated from the industry's wastepaper processing sector normally undergoes manual transfer from generation points to outside containers. Some larger wastepaper operations utilize conveyor systems, but wheeled carts of various types are used for temporary storage and transportation to other storage and collection points. Mechanical conveyor systems represent the only feasible alternative to today's predominant methods because of the solid

FIGURE 9

CONVERTAINER HOIST SPECIFICATIONS*


75¼"
189"
160" LENGTH OF DECK
120"
130¼"
94½"
105½"
11"
TRUCK FRAME
39"-43"*
9½"*

*Dimensions marked with asterisk will vary with truck chassis. Those shown are for a 38" height.

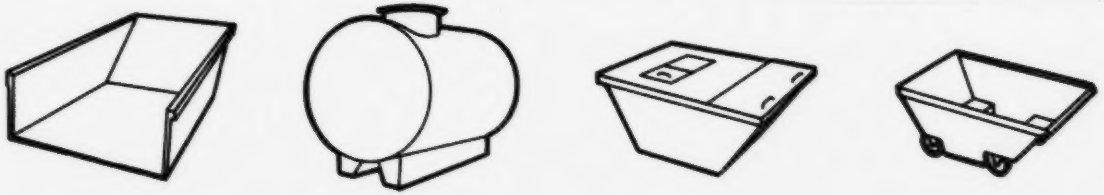
Model	120-H-15	120-H-20	120-H-26
Loading cap'y	15,000#	20,000#	26,000#
Wgt. of hoist	6700#	7200#	7500#
Cyl. size	7" x 45"	8" x 45"	9" x 45"

	Centimeters	Inches
Width Overall	242.6	95.5
Width Inside Of Arms	190.5	75.0
Width Outside Of Arms	228.6	90.0
Width Of Deck	165.1	65.0
Cab To Trunnion Center (Tandem Axle)	304.8	120.0
Cab To Axle (Single Axle)	350.5	138.0
Cab To End Of Frame	447.0	176.0

Container Capacity	6–17 Cubic Meters	8–22 Cabic Yards

FIGURE 10

SAMPLE CONTAINERS HANDLED BY CONVERTAINER SYSTEM*

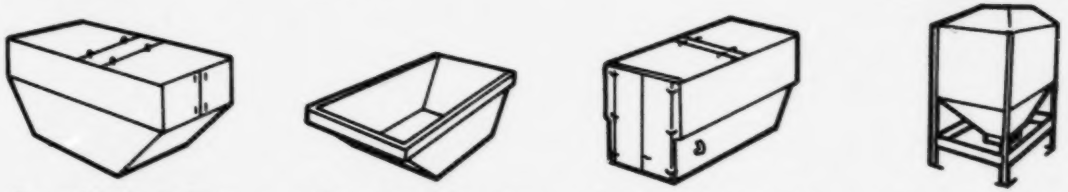


With or without ramp gate. For heavy materials, machinery

Tanks are application-engineered for fluids, fire foam, etc.

For special sludge, fluids, wastes, etc.

Casters, V-wheels, flanged wheels, rollers optional on all containers

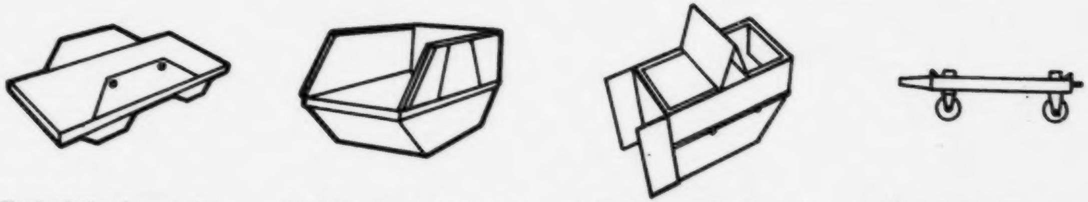


For rubbish, garbage, sludge, etc.

Pick up or dump from either end: sand, ashes, gravel, rubbish

Sizes from 4 to 22 cubic yards for rubbish, big-bulk applications

For bulk feed, dry chemicals, powdered materials



Flat beds for drums, pipe, lumber, machinery

Hi-sides from 3 to 18 cubic yards for scrap and raw materials

Handles—rubbish and big bulk applications.

Dolly pipe used for transporting containers from truck docks to departments.

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*From Converto, Division of Golay and Company, Inc.

waste characteristics. This waste contains a high percentage of metals, glass, and other dense material that makes slurry or pneumatic collection difficult and expensive. Thus, either conveyor systems or small scooter units to haul containers are best suited for collecting wastepaper processing solid waste.

Overall, solid waste collection and storage in the pulp and paper industry consist of bulk materials handling situations rather than collection of numerous small point sources. Thus, all efforts to deposit solid waste directly into collection units (detachable containers) and to reduce total vehicle numbers, manpower requirements, and front-end loader type pickups will lead to greater efficiency.

Processing

Solid waste processing in the pulp and paper industry is limited to a small number of waste generation points and does not represent technological depth or innovation. Only the basic processing schemes used for a long time period have been adopted by the industry for solid waste processing.

Compaction. Only a limited number of stationary compaction units are used in the U. S. pulp and paper industry. These are primarily for personnel, office, manufacturing services, and other miscellaneous bulky solid wastes. The major solid waste sources (bark, sludge, ash, etc.) are not readily compactable and no volume reduction can be obtained by using compaction equipment.

Future compaction equipment use in the industry is not foreseen as a major growth area. Only in mills where integrated solid waste management is undertaken and in specialty product mills where large quantities of nonpulpable broke are generated will compaction units prove feasible. If a limited number of collection vehicles handling various container types are employed, compaction equipment may decrease collection frequency for miscellaneous solid waste sources sufficiently to warrant installation.

As a general rule, compaction equipment will experience limited usage in the pulp and paper industry primarily because of the noncompressible nature of major solid waste sources.

Size Reduction. As with compaction equipment, size reduction equipment for solid waste processing has received limited application because the major solid wastes do not lend themselves to this type of processing. The primary use to date has been to reduce the bark particle size to improve combustion operations. To a lesser extent, it has been used to prepare other solid waste for combustion in hog fuel boilers.

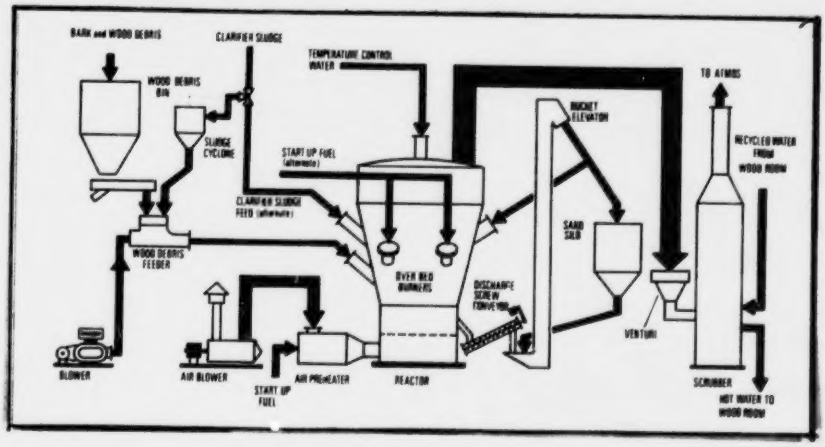
The prevalent size reduction unit has been the hammermill type which consists of hammers rotating about either a horizontal or vertical axis with reduced particle size material exiting through desired size grate openings. No significant advantage exists to stimulate size reduction of additional pulp and paper industry solid waste categories. Increased usage will result as mills attempt to use a larger percentage of the combustible solid waste as a fuel source.

Thermal Reduction. The use of heat to reduce the solid waste volume and to reclaim valuable energy represents this industry's most significant solid waste processing operation. Incineration simply to reduce solid waste volume was used extensively in the form of pit or trench incinerators and teepee burners to process combustible solid waste materials such as bark, pallets, miscellaneous trash, etc. However, air pollution considerations have nearly eliminated these practices at the present time.

Current thermal reduction methods focus on power and steam boilers to utilize the fuel value of combustible solid waste, particularly bark. Previous information has indicated that nearly ten million metric tons (over 10 million tons) of wet bark were burned in 1971, thus indicating the popularity of this approach to bark disposal. With pressures to reduce all waste streams and to conserve fuel supplies, solid waste use as a fuel is going to receive additional attention. The latest innovations in the pulp and paper industry relative to incineration are the application of techniques previously demonstrated for other applications. For example, fluidized bed combustion (Figure 11) has been used for chemical recovery applications in the pulp and paper industry, but has only recently been used to process solid waste including bark, wood debris, and wastewater treatment plant sludge at Great Lakes Paper Company Ltd. in Thunder Bay, Ontario, Canada. However, rather than use a waste heat boiler, this system produces hot water for woodroom showers from the scrubbing system thus freeing previously used steam for other purposes. Future designs will utilize various techniques to efficiently recover the available energy. This process has the advantage of accepting wet

FIGURE 11

COPELAND FLUIDIZED BED PROCESS APPLIED TO SOLID WASTE COMBUSTION


BARK and WOOD DEBRIS
CLARIFIER SLUDGE
TEMPERATURE CONTROL WATER
TO ATMOS
WOOD DEBRIS BIN
SLUDGE CYCLONE
START UP FUEL (alternate)
BUCKET ELEVATOR
RECYCLED WATER FROM WOOD ROOM
CLARIFIER SLUDGE FEED (alternate)
SAND SILO
WOOD DEBRIS FEEDER
OVER BED BURNERS
DISCHARGE SCREW CONVEYOR
VENTURI
BLOWER
AIR BLOWER
START UP FUEL
AIR PREHEATER
REACTOR
SCRUBBER
HOT WATER TO WOOD ROOM

sludge (25 - 28% solids) and wet bark both direct from the debarking drums and from bark piles that have accumulated on mill property. While existing furnace designs can accept high moisture solids; dewatering, drying with flue gases, or supplementary fuel are needed for successful operation. These activities add expense and require energy for operation, while the fluidized bed process can burn fuels with up to 70 percent water without supplementary fuel or pretreatment. While the Great Lakes system has not generated any long term economics, the labor (1.3 man-days per day) and maintenance are expected to be low and a $300 per day credit is given for steam savings. This 160 metric ton (180 ton) unit was constructed in 1972 for about $1,000,000(15). Thus, this combustion process has many potential applications to efficiently utilize the energy value of combustible solid wastes with less limitations than conventional waste heat systems.

Sludge incineration alone with heat recovered only for sludge drying purposes is utilized in the industry, but does not appear to produce a solution as economical as do more complete energy recovery systems. Rietz Manufacturing Company produces one variety of this system (Figure 12) and has units operating in several industry mills.

Bark boilers are now being recognized as wood refuse fired boilers and three major factors are affecting today's design. First, boiler size is increasing to accommodate the larger waste volumes being used for fuel. Second, fuel patterns are changing with the use of combination firing increasing. Third, air pollution requirements are making more efficient combustion with lower particulate emissions necessary.

Basic furnace types such as dutch-oven with grates or refractory bottoms, moving flat grate, inclined grate, and suspension-fired are commonly used for bark combustion(1).

Pulp and paper industry technology handbooks and reference sources discuss bark combustion and furnace design in detail. However, several general features important to all bark or waste wood burning units are(16):

Minimum labor to handle fuel and ash.

Handling, control, and feeding equipment to deliver the correct fuel type and mixture

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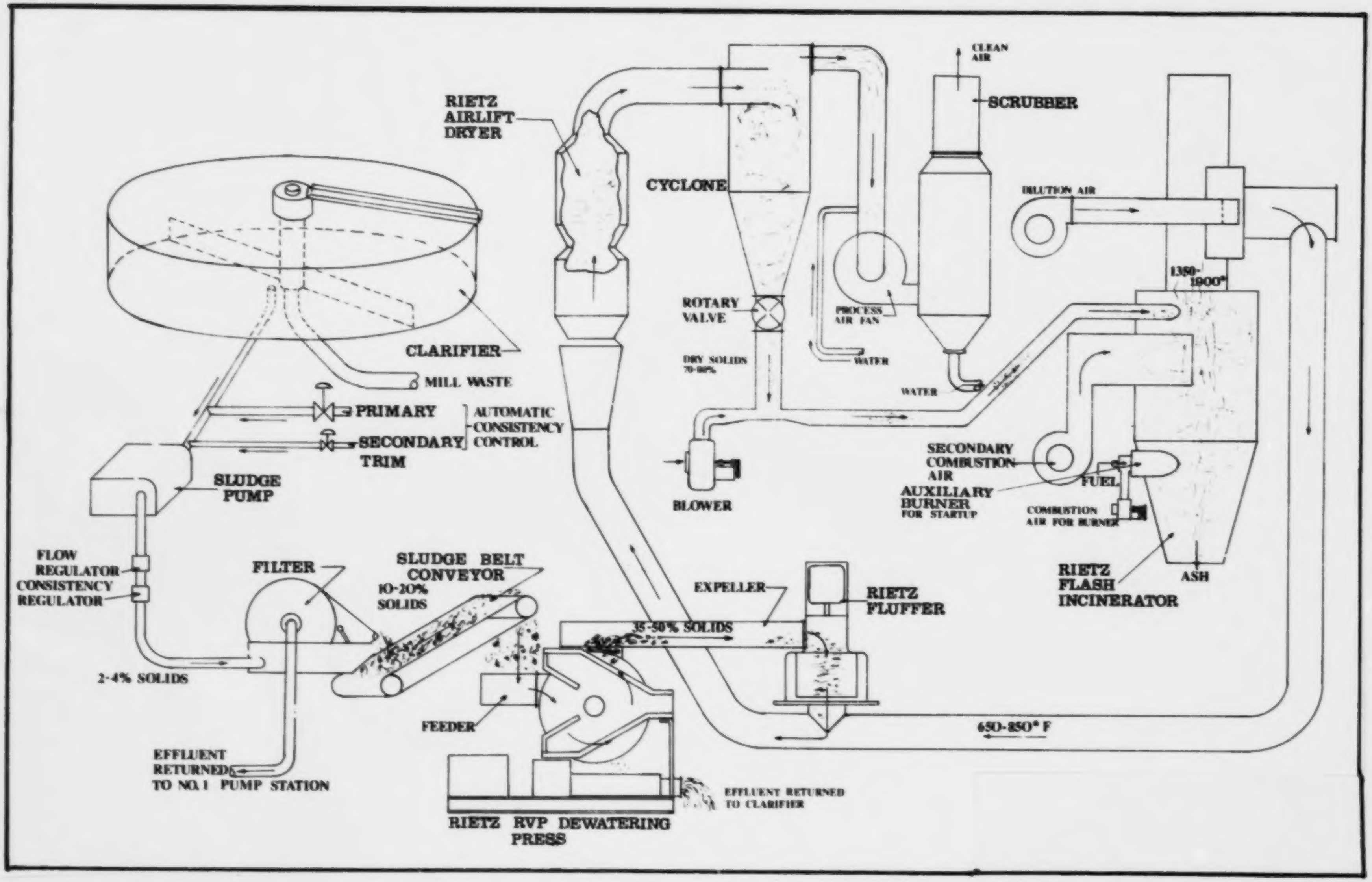
[1], p.352-356.

FIGURE 12

SLUDGE INCINERATION SYSTEM*


RIETZ AIRLIFT DRYER
CYCLONE
CLEAN AIR
SCRUBBER
DILUTION AIR
1350-1900°
ROTARY VALVE
PROCESS AIR FAN
DRY SOLIDS 70-80%
WATER
WATER
CLARIFIER
MILL WASTE
PRIMARY
SECONDARY TRIM
AUTOMATIC CONSISTENCY CONTROL
SLUDGE PUMP
BLOWER
SECONDARY COMBUSTION AIR
FUEL
AUXILIARY BURNER FOR STARTUP
COMBUSTION AIR FOR BURNER
FLOW REGULATOR
CONSISTENCY REGULATOR
FILTER
SLUDGE BELT CONVEYOR
10-20% SOLIDS
EXPELLER
35-50% SOLIDS
RIETZ FLUFFER
RIETZ FLASH INCINERATOR
ASH
2-4% SOLIDS
FEEDER
650-850° F
EFFLUENT RETURNED TO NO.1 PUMP STATION
EFFLUENT RETURNED TO CLARIFIER
RIETZ RVP DEWATERING PRESS

*From Rietz Manufacturing Company

Control and supply of overfire air

Adequate furnace volume and height

Heating surfaces designed for easy cleaning, shedding of build-up, and free of baffles

Tubular air heater where economically justified selected for desired efficiency

System for particulate collection and other applicable air pollution control

System for handling collected particulate matter and other pollutants

Mills not currently utilizing bark and wood wastes for their fuel value will investigate such usage in the future. With the limitations increasing that govern land disposal of solid waste, alternate uses for bark will become more attractive for all mills. Only small mills that cannot economically justify the capital expenditure will continue to use land disposal for all their wood processing solid waste.

Mills currently using bark boilers will undertake programs to maximize bark consumption. Wood yard solid waste that is generated prior to debarking operations, long log slasher sawdust, and other miscellaneous generation points can be utilized in existing boilers if a collection and feeding system can be provided. Improvements at many mills will occur in the bark utilization area. Also, efforts will continue to determine alternate uses for bark and to evaluate the effect of whole tree chipping thus eliminating bark removal as a necessary process. Other efforts will focus on technology to separate bark from chips resulting from whole tree chipping or to produce pulp without removing the bark. While the implementation of any of these industry changes cannot be predicted at this time, they would alter the manner in which bark is currently collected and transported to combustion points, as well as possibly altering combustion techniques.

Bark boilers of conventional design plus fluidized bed combustion units will provide solid waste volume reduction and energy recovery functions to an increasing segment of the industry by 1980. Actual choice of combustion systems will depend upon local conditions, fuel supplies, compatibility with existing equipment, and related variables. Such decisions are generally based on the comparative economics of the systems that can meet technological requirements. Despite additional air pollution restrictions; improved designs, better operational controls, and more efficient air pollution control equipment will allow increased utilization of such units for solid waste management functions.

Resource Recovery. Other than internal process measures to reduce raw materials losses, resource recovery activities have centered on energy recovery from bark wastes which was just discussed under thermal reduction processing. With large power and steam requirements, the industry has seen the advantages of recovering value from its largest solid waste source. While economically attractive for many mills, the savings per unit weight of recovered solid waste will decrease as mills expend more effort to recover a larger percentage of the wood processing solid wastes.

The other routine resource recovery practice within the industry is the sale of salvaged secondary materials. This practice has a small economic return, but does relieve the mill of much unwanted material while providing the small return. Little effort is expended to make these operations more efficient. At most, some mills have one or two men who reclaim items usable internally and categorize material for external sale. The need for more extensive efforts cannot be economically justified.

The industry's fastest growing solid waste category also holds the greatest unutilized resource recovery potential. Several possibilities exist to provide more satisfactory (from both environmental and economical viewpoints) management of primary wastewater sludge than current land disposal and lagooning practices. Some sludges may be usable in secondary fiber mills as a low value furnish for the inner plys of multi-ply paperboard or for other low grade products such as roofing felt, peat pots, molded products, etc. Economic transportation distances will be a critical variable relative to such uses but basic feasibility studies should be undertaken to determine the required conditions for such uses. Also, combination systems using sludge, wastepaper, and resins show the potential of producing either salable products or products for internal use such as pallets, skids, etc.

A recent EPA study(8) plus private company efforts indicate that land disposal of primary wastewater treatment plant sludge as a soil conditioner may be feasible. It was also shown to be usable for hydromulch application either alone or in combination with bark. Recovery of filler pigment from coated paper mill sludges was evaluated by S. D. Warren Company, a Division of Scott Paper and found to be technologically feasible but not economical. It is expected that changes in the industry's raw materials supply and demand plus environmental costs will gradually provide greater implementation of these and other sludge utilization concepts.

The use of bark wastes for mulch or for production of salable products has been investigated, but primarily by the lumber industry(6). Mulch and bark compost are both sold commercially, but market potential is limited for such products. The use of bark as a feedlot litter material has been demonstrated, but this only passes the disposal problem from the pulp and paper industry to the feedlot operation. The forest products industry is currently using bark to produce structural products and has plans to extract both wax and chemicals on a commercial level(17). While most of this bark utilization effort has been fostered by the lumber processing industry, similar approaches are applicable to the pulp and paper industry.

Resource recovery opportunities for the smaller solid waste generation points have not received any attention and will not unless a direct sale of such material or simple recovery system is presented to the industry. This approach has been fostered by their small contribution to the total solid waste generation quantity. Principal efforts will focus on methods to combine combustible solid wastes with other hog fuel sources to recover the energy value. Sources of these wastes include manufacturing services, personnel activity, groundwood shives, residuals losses, and other miscellaneous solid waste sources.

Overall, the industry has and will continue to focus external resource recovery activities on energy reclamation. The one area with sufficient cost saving and profit potential to possibly change this focus is primary wastewater treatment sludge. The diversity of sludge characteristics and large sludge quantities should exhibit significant product possibilities to encourage industry leaders to evaluate the technical and economic feasibility of sludge utilization alternatives.

Disposal

The pulp and paper industry's solid waste disposal operations represent the most lax aspect of most individual mill systems. Nearly all mills operate land disposal sites that occupy the nearest available land. Little initial design or operational plans were normally included and most sites receive intermittent cover at best. Thus, the present industry disposal methods will soon be forced out of existence to be replaced by more costly land disposal systems (Chapter VIII).

With most large integrated mills located in nonurban areas, the use of properly designed and operated sanitary landfills will become the predominant disposal method at a cost much greater than that expended at present. Smaller, nonintegrated mills in more urban areas will increase the use of commercial solid waste contractors with the solid waste being transported to either public or private disposal sites. For these mills who (1) use market pulp (no bark or pulping solid waste); (2) use purchased power (no coal ash); and (3) utilize joint public/industrial wastewater treatment facilities (no wastewater treatment sludge); the magnitude of their solid waste problem becomes much easier to control.

While other solid waste management practices do not always provide the best or most efficient service, the disposal operations are the only class of activities that are generally inadequate. However, it is expected that when disposal facility upgrading is forced, the industry will review their overall solid waste management systems to determine what total cost savings may be realized.

The technology required for sanitary landfill design and operation is not sophisticated or difficult to implement. It has been published by the EPA(18) and simply requires proper planning, operation, and a systematic approach plus a management conviction to meet the required performance level.

While sludge lagooning will remain prominent in the industry for sludge disposal, its relative use will decrease in the future. Lack of available inexpensive land will be the primary initial cause, but application of stringent environmental restrictions (groundwater contamination, flooding danger, effluent restrictions, etc.) will increase the cost of sludge lagooning. Also some mills have found that lagoon life is not as great as predicted thus requiring expensive dredging and land disposal or new lagoon construction. These factors will divert the industry toward increasing use of dewatering technology thereby transferring primary sludge to the solid waste management system. As the total quantity of dewatered sludge requiring land disposal increases, the use of sludge incineration and sludge combustion in hog fuel burners will increase to reduce the materials handling problem. Thus, while the percent of total primary sludge dewatered increases, the percent undergoing combustion will also rise. However, because of increasing production and effluent treatment, all final sludge disposal methods (lagooning, landfill, and combustion) will show total quantity increases. However, the percent of total sludge to disposal will be rising for combustion, falling for lagooning, and remaining nearly constant for landfill. Estimated quantities undergoing each type of disposal were estimated for 1975 and 1980 (Table 36).

TABLE 36

ESTIMATED PRIMARY SLUDGE DEPOSITION*

Metric Tons (Tons)**

	Lagoons		Combustion		Land Disposal		Total	
	Minimum***	Maximum***	Minimum***	Maximum***	Minimum***	Maximum***	Minimum***	Maximum***
1971	1,034,000 (1,140,000)	2,217,000 (2,444,000)	239,000 (264,000)	513,000 (566,000)	399,000 (440,000)	855,000 (943,000)	1,673,000 (1,844,000)	3,585,000 (3,953,000)
1975	1,413,000 (1,558,000)	2,583,000 (2,848,000)	565,000 (623,000)	1,033,000 (1,139,000)	848,000 (935,000)	1,550,000 (1,709,000)	2,826,000 (3,116,000)	5,166,000 (5,696,000)
1980	1,514,000 (1,669,000)	2,645,000 (2,916,000)	1,135,000 (1,251,000)	1,984,000 (2,187,000)	1,135,000 (1,251,000)	1,984,000 (2,187,000)	3,783,000 (4,171,000)	6,612,000 (7,290,000)

*From Gorham International Inc.

**All Weights Expressed As Dry Weights

***Ranges Result From Raw Waste Load Data - Use Average For Calculations

Disposal of sewage and water treatment sludge are two areas that also interface with solid waste management. Sewage sludge represents a minimal contribution, but is included with wastewater treatment sludge when jointly treated. However, because of possible bacterial contamination, the industry normally separates sanitary sewers for inclusion in municipal systems, septic tank disposal, or small package treatment plants. Water treatment sludge is often returned to a watercourse, but current legislation will require that these effluents enter wastewater treatment facilities. This will add a small amount to total sludge, but will not materially affect total quantities or characteristics.

One point that is in the industry's favor is the general lack of hazardous or toxic components in its solid waste. The use of PCB's has been eliminated with current sources found infrequently in wastepaper supplies coming from prior production. Also, the FDA has established limits for PCB's in paperboard used in the food industry and the decreasing quantities should rapidly be eliminated from wastepaper sources. Also, mercury from chlor-alkali plants and mercury slimicides have been essentially eliminated by changes in industry practices away from these process uses. Thus, hazardous and toxic components in the industry's solid waste do not constitute a serious problem.

Technological Alternatives

Pulp and paper industry solid waste management systems approximate municipal situations very well. The historical development has led to a diffuse system that has not resulted from planned activity or from systematic approaches. The day to day routine has expanded in a helter-skelter fashion simply to remove accumulated solid waste to the nearest available land.

Unlike the municipalities, who have been offered demonstration grants and technical assistance, the pulp and paper companies have had no incentive to improve existing systems. Because of centralized generation points and short haul distances, the costs per unit weight have not reached the levels of municipal solid waste management. Thus, with environmental pressures focused on industrial air and water pollution, minimum attention has been given to solid waste problems.

Except for disposal operations, the technology in use is not inadequate from any point of view except that in most instances it does not provide the optimum service. Thus, as has been shown for municipal operations, a thorough study of the individual solid waste management system can be very effective in providing improved service without cost increases. Taking a relatively modern integrated pulp and paper mill complex producing about 900 metric tons (1,000 tons) per day, improved collection plus satisfactory sanitary landfill disposal could be provided for nearly the same cost as today's conventional system. In fact, if ample storage facilities were made available, total costs for the improved system could be made lower than for conventional systems. While only a hypothetical example, this illustration points out the type of potential possible by simply attempting to maximize equipment and labor utilization. For the system described above, it is estimated that 300 to 500 metric tons (270 to 450 tons) per day could be handled depending on local conditions (haul distances, mill layout, etc.).

To provide the cost savings indicated while at the same time upgrading disposal operations, a mill would have to carefully establish operating schedules and criteria. The following discussion presents the type of changes required to implement an improved solid waste management system (Table 37).

Internally, the three laborers estimated for the conventional system would be replaced by a laborer/driver who would use a scooter with a truck dump body (depending on space, a pick-up or trailer compaction unit might be used). Miscellaneous solid waste would be transported to a stationary compactor and salvageable material would be deposited in separate removable containers.

External collection would shift from several trucks working primarily on the day shift to one unit capable of handling all the containers and working two or three shifts per day. Power generation ash would be deposited into a removable container continuously or from the ash storage hopper if one were available from the previous system. Similarly dewatered sludge transported to land disposal would be deposited either directly into a container or into a pile for subsequent container loading. A one-half time front end loader would still be used to pick up miscellaneous solid wastes plus possible sludge loading from a storage pile.

Disposal operations would change from receiving minimal unplanned attention to having a bulldozer operating at the site during the entire time solid waste is being deposited. This attention coupled with proper design should provide an acceptable sanitary landfill.

The projected costs for this improved operation provide for nearly full time collection and disposal operations (three eight hour shifts per day for five days per week). Under current practices, operations generally consist of basically day shift work with only emergency situations attended to during other time. Therefore, if ash silos and sludge stockpiling are acceptable, it is estimated that operating one less shift per day would be feasible under normal circumstances. This type operation would decrease operating costs by about $67,000 resulting in nearly a $50,000 cost saving over the conventional system.

This illustration points out that while it is predicted that the pulp and paper industry will spend an increasing dollar amount to improve disposal operations, the potential exists to offset this expense by improving other system aspects.

Overall, the pulp and paper industry can provide more efficient solid waste services by adapting available collection and handling procedures and equipment available from municipal and commercial sectors. It is unlikely that the industry will undertake any efforts to develop new solid waste management technology. However, major efforts will be undertaken to apply available technology to solid waste management problems. The primary activities will deal with meeting state imposed disposal standards, increasing fiber and energy recovery, and developing new uses for solid waste components (particularly primary wastewater sludge). Energy recovery economics from bark wastes were presented earlier and indicated sufficient economic incentives to warrant capital expenditures. Resource recovery activities related to sludge are in an infant stage and no realistic economics can be presented at this time. However, as sludge quantities increase, industry officials should expend considerable effort developing the possible alternatives.

Basically, solid waste technology is expected to follow past trends with technological actions taken when prompted by regulatory powers or favorable economics.

TABLE 37

CONVENTIONAL VS IMPROVED SOLID WASTE MANAGEMENT SYSTEM
(900 Metric Ton/1,000 Ton Daily Production Capacity)

Conventional System

Labor Cost	
Internal	
3 Laborers (2,080 hrs x $4.50/hr x 3 men)	$ 28,080
External	
1 Ash Truck Driver (2,080 hrs x $5.50/hr)	$ 11,440
1 Container Hauling Truck Driver (2,080 hrs x $5.50/hr)	11,440
2 Sludge Truck Drivers (2,080 hrs x $5.50/hr x 2)	22,880
.5 Dump Truck Driver (1,040 hrs x $5.50/hr)	5,720
.5 Front-End Loader Driver (1,040 hrs x $5.50/hr)	5,720
Total Labor Cost	$ 85,280
Equipment Cost	
Internal	
No Allowance Made For Drums & Broke Carts	$ 0
External	
1 Ash Truck (2,080 hrs x $12.75/hr)	$ 26,520
1 Container Hauling Truck (2,080 hrs x $12.75/hr)	26,520
2 Sludge Trucks (2,080 hrs x $12.75/hr x 2)	53,040
.5 Dump Truck (1,040 hrs x $12.75/hr)	13,260
.5 Front-End Loader (1,040 hrs x $7.50/hr)	7,800
Container Depreciation ($20,000/10 yr life)	2,000
	$129,140
Total Cost	$214,420

(Continued On Next Page)

TABLE 37
(Continued)

Improved System

Labor Cost	
Internal	
1 Laborer/Driver (2,080 hrs x $5.50/hr)	$ 11,440
External	
3 Container Hauling Unit Drivers (2,080 hrs x $6.00/hr x 3)	37,440
.5 Front End Loader Driver (1,040 hrs x $5.50/hr)	5,720
Disposal	
3 Bulldozer Operators (2,080 hrs x $6.00/hr x 3)	37,440
Total Labor Cost	$ 92,040
Equipment Cost	
Internal	
1 Scooter With Trash Dump Body (2,080 hrs x $1.00/hr)	$ 2,080
New Standard Trash Containers Depreciation ($5,000/10 yr life)	500
External	
1 Large Container Hauling Unit (3 shifts x 2,080 hrs x $12.75/hr)	79,560
.5 Front-End Loader (1,040 hrs x $7.50/hr)	7,800
Compacter ($10,000/10 yr life)	1,000
Containers ($32,000/10 yr life)	3,200
Disposal	
1 Bulldozer (3 shifts x 2,080 hrs x $7.50/hr)	46,800
	$140,940
Total Cost	$232,980

*From Gorham International Inc.

Potential Impact Of New Industry Technology

As in all industrial situations, process improvements and modifications are continuously sought by the pulp and paper industry to produce a better product or to minimize total operating costs. While these changes cannot be predicted with any degree of certainty, several potential technology shifts could have an impact on the industry's solid waste management systems.

With fiber supply, environmental, and economic pressures, mills have looked to relaxing bark tolerance levels for kraft pulping. A recent study by the Department of Agriculture's Forest Products Laboratory(19) indicated that, considering capital and operating cost for a new mill, roughwood pulping is more economical than providing debarking operations plus helping extend our wood supply. While bark boiler operation would not be required, only minor reductions in solid waste to disposal would result from this process alteration. Instead of being removed by a debarking system and going to the bark boiler, this bark will go to the digester and be removed with the black liquor for combustion in the recovery furnace. However, bark wastes that are knocked off from roundwood in the wood yard prior to chipping will still remain as solid wastes. This is the major portion of the bark that currently goes to disposal sites in mills with bark recovery and combustion systems. Thus, while resource recovery techniques would undergo considerable change, total solid waste to disposal would follow basically the same declining pattern as predicted for conventional debarking and bark burning.

Efforts are also being made to provide economical methods of removing contaminants from the wood yard bark to enable use in conventional bark boilers without excessive erosion and operating problems . If economic methods to clean up this bark waste become available, total bark to solid waste could be greatly reduced, particularly if energy shortages continue to exist.

Pulping systems designed to reduce air and water pollution problems are a subject of great interest to the industry. However, with the minimal solid waste generated directly from pulping operations, only wastewater treatment plant sludge reductions would be significant to the solid waste management systems. Similarly, oxygen bleaching or other new bleaching techniques would not be expected to greatly affect solid waste management operations.

The wastewater treatment area does hold another potential solid waste problem. Proposed federal guidelines for 1983 call for extensive color removal from the industry's liquid effluent. While only a limited number of mills currently practice color removal, much speculation exists regarding what technologies will provide the most economically feasible solution. While sludge generation can be a factor in color removal process, the industry will look most favorably upon systems that enable combustion of by-products or subsequent reuse. Lime systems that enable raw material recovery and systems that enable energy recovery from removed contaminants represent the two major classes of color removal systems from a solid waste management viewpoint. Thus, while some installations will generate currently unknown sludge quantities, installation of full scale color removal processes will focus on those approaches not limited by high sludge generation rates and costly disposal operations. A good review of color removal techniques from the worldwide pulp and paper industry has been compiled in a recent publication(20).

While process improvements and changes will undoubtedly occur over the next decade, the impact on solid waste management is expected to be minimal. Because major changes require large capital expenditures, they will normally be applied only to new mill installations until they are thoroughly tested and proven. Thus while individual mills may experience specific new solid waste management problems, no significant overall industry impact is expected.

CHAPTER X

CONCLUSIONS AND RECOMMENDATIONS

Solid waste management in the pulp and paper industry, like most other industrial and municipal situations, has been traditionally treated like the unwanted stepchild. The primary concern has been to maintain normal production operations without being hindered by solid waste problems. Thus, the industry has simply expended funds adequate to remove solid waste from generation points to the closest possible available land with little or no attention given to the adequacy of operation. Only economically attractive resource recovery opportunities have received overall industry support.

As a result of the above general approach to solid waste management, nearly all of the from 14.3 to 16.2 million metric tons (15.8 to 17.8 million tons) of pulp and paper industry generated solid waste in 1971 received inadequate disposal. While industry costs averaged $4.26 per metric ton ($3.86 per ton) of solid waste, inefficient collection and handling operations predominate in this industry. Generally, no single department or individual has complete authority or responsibility for solid waste management activities. Many times operating departments have at least partial responsibility for their own solid waste collection, transportation, or other aspect with no clear management or operational program in existence. Another common practice is to assign solid waste management responsibilities to the yard or maintenance crew who have no technical background or capabilities to undertake organization of a more efficient solid waste management system.

Despite the lack of overall concern with solid waste management, the industry has decreased solid waste generation per unit of production by increasing raw material utilization and adopting internal resource recovery practices where favorable economic advantages were apparent. The previously cited energy recovery from bark combustion plus fiber recovery from liquid effluents have helped to increase overall industry productivity. However, total solid waste quantities have risen from a minimum of 9.8 million metric tons (10.8 million tons) in 1958 to the 1971 minimum level of 14.3 million metric tons (15.8 million tons). Estimated minimum solid waste generation for 1980 is 18.6 million metric tons (20.6 million tons). Thus, as state regulations force improved disposal site operations, the economic impact of managing such large solid waste volumes will encourage the industry to look more closely at upgrading existing solid waste management practices.

With a relatively few major solid waste types, the industry has limited possibilities to pursue in improving solid waste management. To decrease solid waste generation rates, improvements in process efficiency can be maximized. This is a continual evaluation problem, but the industry does attempt to minimize spillage losses and to increase process productivity. For example, in the chemical recovery area, solid waste generation may be minimized by providing the best possible operating conditions. This enables maximum conversion of recovery furnace smelt to usable cooking liquor with only inerts exiting as solid waste.

Outside the major process areas, energy recovery from combustible solid waste represents a prime target for resource recovery. The industry utilizes large amounts of power with most being generated internally. Thus power generating facilities exist and utilization of solid waste as fuel reduces the solid waste volume and lowers external fuel costs. This practice is currently widespread within the industry, but additional emphasis will be placed on miscellaneous solid waste categories (personnel, manufacturing services, etc.) to reclaim available energy value.

Once the usable categories have been exhausted, the industry must either provide disposal facilities or find by-product markets and uses for the remaining solid waste. Land disposal facilities will be a necessity for most industry installations, but by-product sales exhibit potential to reduce total solid waste quantities. Particularly in the primary wastewater treatment sludge category, the pulp and paper industry possesses a unique solid waste. Major efforts should be undertaken to develop products made from this fibrous sludge alone or in combination with other components. Structural products, low-grade construction paper, molded products, soil conditioners, etc. represent possible outlets that will minimize solid waste disposal problems.

Once all usable materials have been removed, the use of improved management methods can provide the most economical solid waste operations. While the pulp and paper industry is very unlikely to be innovative in basic solid waste management technology, they can make use of available equipment to provide the best possible service. Existing container hauling vehicles with low capacities can be replaced with vehicles capable of transporting a variety of containers suited to specific waste materials. Labor intensive collection practices and inefficient operations (manual internal collection, front-end loader and dump truck collection, etc.) can be replaced by more automated and mechanical approaches. Two and three shift utilization of expensive capital equipment can help provide the most economical use of available resources.

Sanitary landfill operation will become prevalent within the industry and will require additional design efforts, equipment, and labor. However, if the approach taken is to improve overall system operations, the additional costs should be absorbed by savings in the storage and collection activities.

Overall, the pulp and paper industry does not have any toxic, hazardous, or extremely difficult to handle solid waste. The primary problem is the large solid waste quantity that represents a bulk materials handling problem. As in other environmental areas, no automatic solution exists. Each individual mill requires a tailored system to best satisfy specific needs. Thus, while the industry as a whole should pursue resource recovery opportunities and improved solid waste management techniques, each mill must undertake efforts to understand and solve its own internal problems.

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APPENDIX A

CASE STUDY SUMMARY

To provide an in depth look at solid waste management practices in several different industry sectors, five case studies were undertaken. The five studies were selected to be a primary data source for major industry sectors. Industry segments were chosen to represent the largest possible percentage of total industry output (Table 1).

TABLE 1

CASE STUDY CATEGORIES*

Case Study Category	Pulp Production Metric Tons (Tons)	Paper Production Metric Tons (Tons)	Paperboard Production Metric Tons (Tons)
(A) Bleached Kraft Pulp, Paper, & Paperboard	10,453,492 (11,525,350)	3,316,684 (3,656,763)	3,175,012 (3,500,565)
(B) Wastepaper Board & NSSC Pulp & Paperboard	3,206,182** (3,534,930**)		7,023,923 (7,744,127)
(C) Coated & Uncoated Printing & Converting Paper		8,181,662 (9,020,576)	
(D) Groundwood & Bleached Sulfite Pulp & Paper	5,632,111 (6,209,604)	4,088,563 (4,507,787)	
(E) Unbleached Kraft Pulp & Paperboard	14,792,367 (16,309,115)		10,829,978 (11,940,439)
Total Production Represented By Case Studies	34,084,152 (37,578,999)	15,586,909 (17,185,126)	21,028,913 (23,185,131)
Total Production In Industry	39,846,941 (43,932,681)	21,620,920 (23,837,840)	23,691,291 (26,120,498)
Percent Of Industry Production Represented By Case Studies	85.5%	72.1%	88.8%

*From Department of Commerce Data - 1971

**NSSC Pulp Only

The original case study concept was to use them to verify information obtained from the literature review. Based on the lack of firm information and data in the technical literature, the case study approach was altered to develop as much hard data as possible. The case study plan involved pre-visit study of the mill's operation, a one to two man-week on-site data gathering phase, and a post visit data evaluation and report writing period (Table 2).

TABLE 2

CASE STUDY PLAN*

Pre-Visit

The following activities were conducted prior to visiting the case study site:

1. Review engineering drawings
2. Produce schematic flow diagrams
3. Become familiar with processes and equipment
4. Locate principal solid waste generation points

On-Site

The following activities were conducted at the case study site:

1. Meet responsible personnel
2. Tour physical plant
3. Arrange to weigh all waste hauling units for tare weights
4. Establish details for weighing all trucks hauling solid waste of any type to processing or disposal areas (will include notation of waste type, plus possible samples to determine density and moisture content) (not conducted at every site)
5. Measure size of all storage containers (also number of containers)
6. Document and photograph solid waste storage, handling, processing, and disposal operations on and off the site

TABLE 2
(Continued)

7. Document recycling operations and possibilities for same
8. Interview mill personnel
   - A. Environmental Director: overall program, equipment in operation
   - B. Production Manager: average daily outputs, yields, raw materials, internally recycled materials
   - C. Wood Yard Superintendent: volume of wood handled, wood room losses, bark handling procedures, equipment, and personnel
   - D. Maintenance Superintendent or other person responsible for trash removal: methods used, approximate volumes or weights, equipment and personnel, obsolete equipment, boiler ash and air pollution control equipment waste, office and cafeteria wastes, wires and felts (possibly boiler plant superintendent also)
   - E. Purchasing Agent: raw materials, nondurable goods purchased, types of containers in which material is purchased, quantity of felts, wires, pallets, flow of goods
   - F. Administrative Offices: official responsible for waste handling system

Post Visit

The following activities were conducted subsequent to visiting the case study site:

1. Develop approximate input-output chart
2. Describe solid waste handling, processing, and disposal methods and equipment
3. Discuss variables affecting waste generation rates

TABLE 2
(Continued)

4. Provide written case study to participating company
5. Discuss with participating companies the relation of their system to others studied

These case studies represent one portion of the overall effort to achieve several contract objectives, all aimed at providing up-to-date information on solid waste management practices and alternatives in the pulp and paper industry.

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*From Gorham International Inc.

This chapter presents a brief description and discussion of each case study mill and their respective solid waste management activities.

Case Study Mill Descriptions

Each case study mill will be identified by the letter that corresponds to the case study category (Table 1). These letters will be used to identify the mills throughout this chapter.

Case Study Mill "A" is situated in the Southern United States and produces bleached kraft pulp, paperboard, and converted paper products. The daily mill output exceeds 815 metric tons (900 tons) per day. The mill site is slightly larger than 445 hectares (1,100 acres) and is bordered by a navigable river which provides the mill's water supply.

Both hardwood and softwood pulp are manufactured, employing six batch digesters, a Kamyr continuous digester, and a recently installed Bauer continuous digester. Wood supplies for the pulping operation consist of hardwood and softwood logs, purchased chips, plus sawdust and shavings obtained as sawmill refuse. The mill uses a pulp dryer to generate a small amount of market pulp, mostly for use in other company mills.

Electrical energy for the mill is produced by two steam turbine driven generators, and the remaining requirement is purchased from a local power company. The mill's seven boilers can provide 680,000 kilograms (1,500,000 lbs) of steam per hour. Water usage is 170,325 cubic meters (45,000,000 gallons) per day, with most of it being returned to the river after receiving primary and secondary treatment. This wastewater treatment includes clarification and over 60 hectares (150 acres) of aeration and holding lagoons.

In addition to the pulp dryer, the mill operates four tissue machines and two paperboard machines. The paperboard is shipped in rolls to converting operations within the company, while the tissue is converted on site into table napkins, bathroom tissue, and towels.

About 1,500 people are employed by the company at this operation to produce more than 815 metric tons (900 tons) of bleached pulp and 815 metric tons (900 tons) of paperboard and paper per day.

Case Study Mill "B" is located in the Midwestern United States and produces NSSC pulp, combination paperboard, and corrugating medium. The daily mill output averages over 635 metric tons (700 tons) per day. The mill site is adjacent to a large navigable river. However, its water supply is obtained from wells to minimize water treatment requirements that would be necessitated by the river's high salt and solids content.

The NSSC pulp is manufactured from purchased chips using a continuous digester of two tube design. The remaining fiber supply is obtained from purchased wastepaper which is separated into four stock systems. The mill operates two Beloit cylinder machines and two Fourdrinier machines.

Steam for the paper machines is obtained from boilers which are adapted to burn coal, oil, or gas. Flyash from the pulverized coal fired boilers is collected by precipitation and sluiced to a dewatering pond.

Water for the mill receives treatment to remove iron with water usage averaging 32,930 cubic meters (8.7 million gallons) per day. The liquid effluent discharge goes to a primary clarifier with the underflow passing to a sludge holding pond.

Nearly 700 people are employed by the company at this location to produce more than 635 metric tons (700 tons) of product per day.

Case Study Mill "C" is situated in the Midwestern United States and produces bleached kraft pulp and various uncoated and coated paper grades. The daily mill output exceeds 726 metric tons (800 tons) of pulp and paper products. The mill site is 142 hectares (350 acres) with a creek flowing through the property.

Hardwood pulp is manufactured using eight batch digesters. Wood supplies consist of purchased long logs, roundwood, and chips obtained from nearby facilities. A small amount of market pulp is produced and sent to other company owned mills. The mill purchases softwood pulp to meet its requirements.

The mill operates two recovery furnaces and three power boilers on pulverized coal plus a small gas-oil package unit for its steam and power requirements. Water usage amounts to more than 132,475 cubic meters (35,000,000 gallons) per day. The mill effluent, after receiving primary and secondary treatment, is discharged to the creek.

Eleven paper machines, all Fourdriniers, manufacture the paper and coating raw stock converted on site. Uncoated grades are finished and shipped in rolls or sheets. Coated grades are also shipped as rolls or sheets. The output includes book paper, duplicator, mimeo, ledger, register bond, and offset grades. Coated printing and specialty printing papers are produced on the mill's off machine coaters.

About 2,400 people are employed by the company at this location to produce more than 454 metric tons (500 tons) of bleached pulp and 726 metric tons (800 tons) of paper per day.

Case Study Mill "D" is located in the Northeastern United States and produces both groundwood and sulfite pulp to use in the manufacture of various uncoated and coated paper grades. The daily mill output exceeds 1,000 metric tons (1,100 tons) of pulp and paper products. The mill site is several hundred acres in size and is served by a river of substantial flow.

Sulfite pulp is produced using eight batch digesters and the output is used partially on site, with a portion used at another company location. Groundwood pulp is manufactured from four foot softwood sticks. Refiner groundwood is produced from purchased poplar chips using disc refiners. Wood supplies consist of purchased roundwood, long logs, and chips.

The mill operates one recovery furnace for the magnesium bisulfite pulping process and four oil fired power boilers. Additional power is generated by hydro equipment. Water usage amounts of 416,350 cubic meters per day (110,000,000 gallons per day) excluding water used for power generation. About 98,430 cubic meters per day (26,000,000 gallons) of mill process water receive primary wastewater treatment.

Eleven paper machines are used on site to produce uncoated papers and basestock for coating. These machines are all Fourdriniers except for one twin wire machine. A four-vat cylinder machine is used to produce wrapper paper. Grades produced at this location are newsprint, uncoated groundwood printing, and coated groundwood printing papers. The coated products are processed on off machine equipment.

About 1,800 people are employed by the company at this site to produce more than 1,000 metric tons (1,100 tons) of pulp and paper per day.

Case Study Mill "E" is located in the Southern United States and produces unbleached kraft pulp and linerboard. The daily mill output exceeds 800 metric tons (880 tons) of paper. The mill site is several hundred hectares in size and borders a small river which receives the treated mill process water.

Softwood pulp is manufactured using nine batch digesters. Wood supplies consist of long logs, roundwood, and purchased chips.

The mill operates three boilers burning oil, gas, or bark and three recovery furnaces to meet its steam and power requirements. Two steam turbines are used for the power generation. Water usage amounts to 43,000 cubic meters per day (11.5 million gallons) and is obtained from wells. The mill process water passes through a primary clarifier and a series of lagoons and holding ponds before discharge to the river.

Two Fourdrinier paper machines manufacture linerboard which is slit into rolls and shipped to other locations for converting.

About 500 people are employed by the company at this location to produce more than 800 metric tons (880 tons) of unbleached kraft pulp and a corresponding amount of linerboard per day.

To provide a better picture of each case study mills manufacturing process, simplified schematic flow diagrams are presented (Figures 1 thru 5). These diagrams illustrate the normal flow of materials and discharge points for process losses.

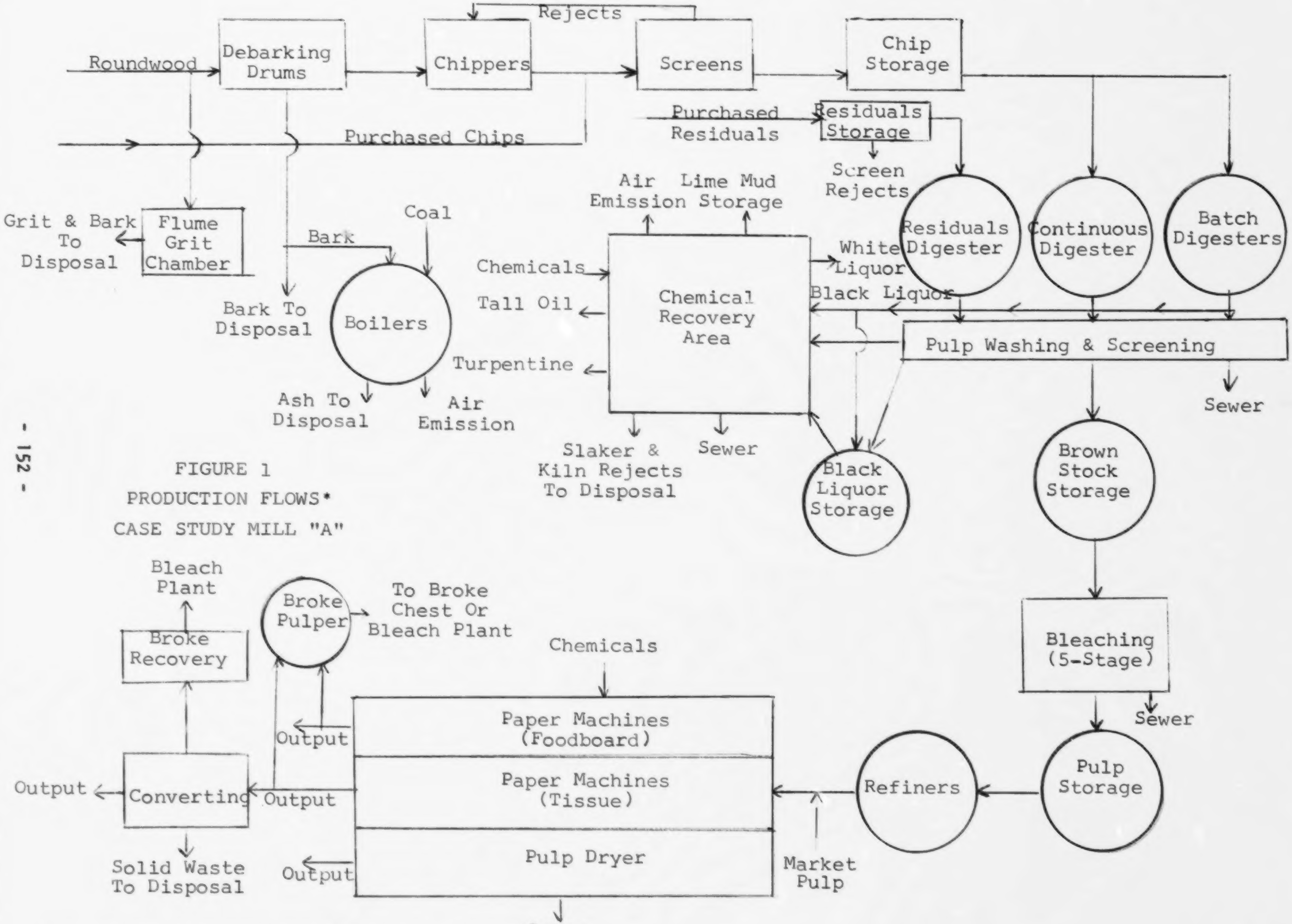
Roundwood
Debarking Drums
Chippers
Rejects
Screens
Chip Storage
Purchased Chips
Purchased Residuals
Residuals Storage
Screen Rejects
Grit & Bark To Disposal
Flume Grit Chamber
Bark
Bark To Disposal
Coal
Boilers
Ash To Disposal
Air Emission
Air Emission
Lime Mud Storage
Chemicals
Tall Oil
Turpentine
Chemical Recovery Area
Slaker & Kiln Rejects To Disposal
Sewer
White Liquor
Black Liquor
Residuals Digester
Continuous Digester
Batch Digesters
Pulp Washing & Screening
Sewer
Black Liquor Storage
Brown Stock Storage
Bleaching (5-Stage)
Sewer
Pulp Storage
Refiners
Market Pulp
Chemicals
Paper Machines (Foodboard)
Paper Machines (Tissue)
Pulp Dryer
Sewer
Output
Output
Output
Broke Pulper
To Broke Chest Or Bleach Plant
Bleach Plant
Broke Recovery
Converting
Output
Solid Waste To Disposal

FIGURE 1

PRODUCTION FLOWS*

CASE STUDY MILL "A"

*From Mill Data and Case Study Data

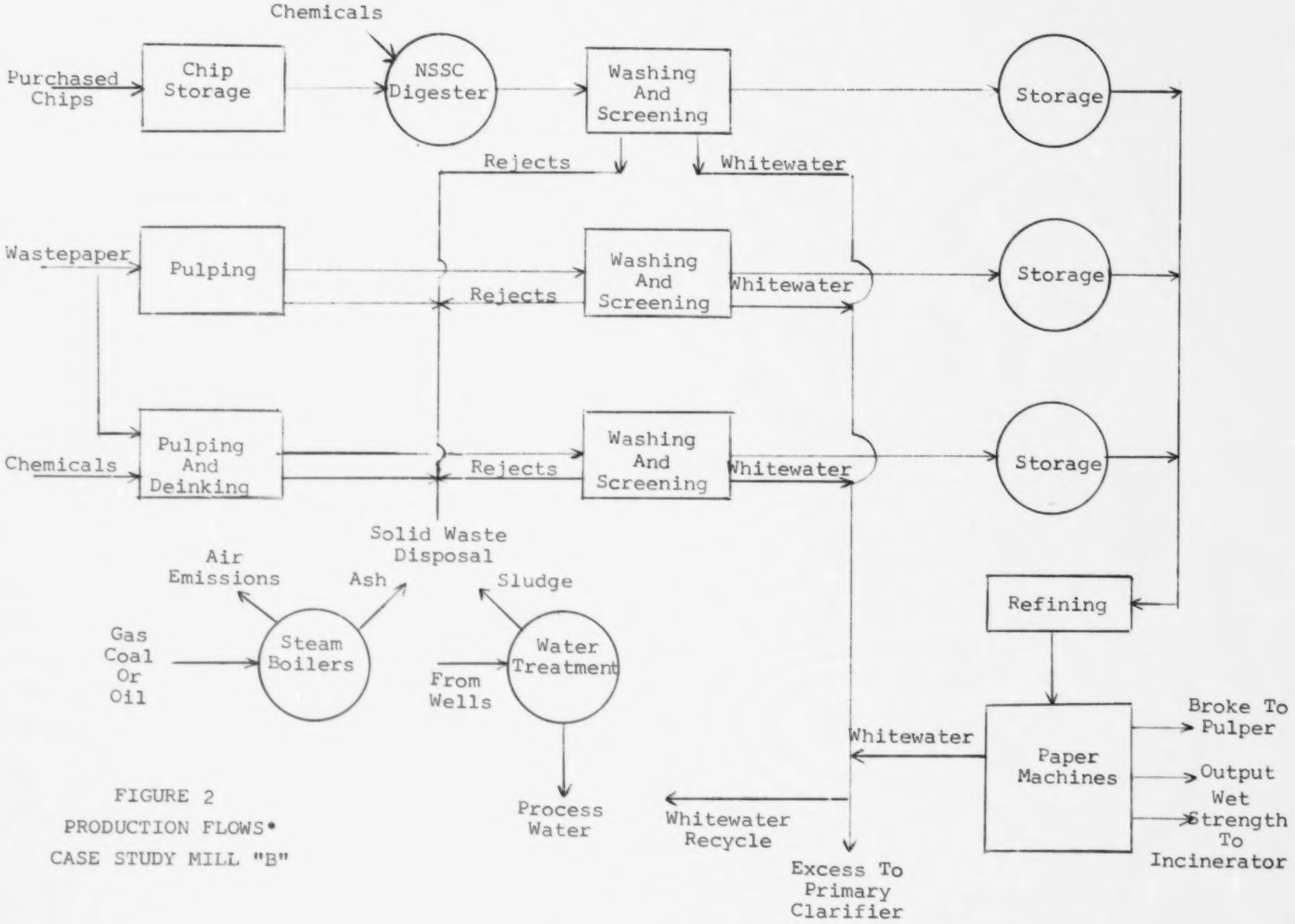
Chemicals
Purchased Chips
Chip Storage
NSSC Digester
Washing And Screening
Storage
Rejects
Whitewater
Wastepaper
Pulping
Washing And Screening
Whitewater
Rejects
Storage
Chemicals
Pulping And Deinking
Rejects
Washing And Screening
Whitewater
Storage
Solid Waste Disposal
Air Emissions
Ash
Sludge
Gas Coal Or Oil
Steam Boilers
From Wells
Water Treatment
Process Water
Refining
Whitewater
Paper Machines
Broke To Pulper
Output
Wet Strength To Incinerator
Whitewater Recycle
Excess To Primary Clarifier

FIGURE 2

PRODUCTION FLOWS*

CASE STUDY MILL "B"

*From Mill Data And Case Study Data

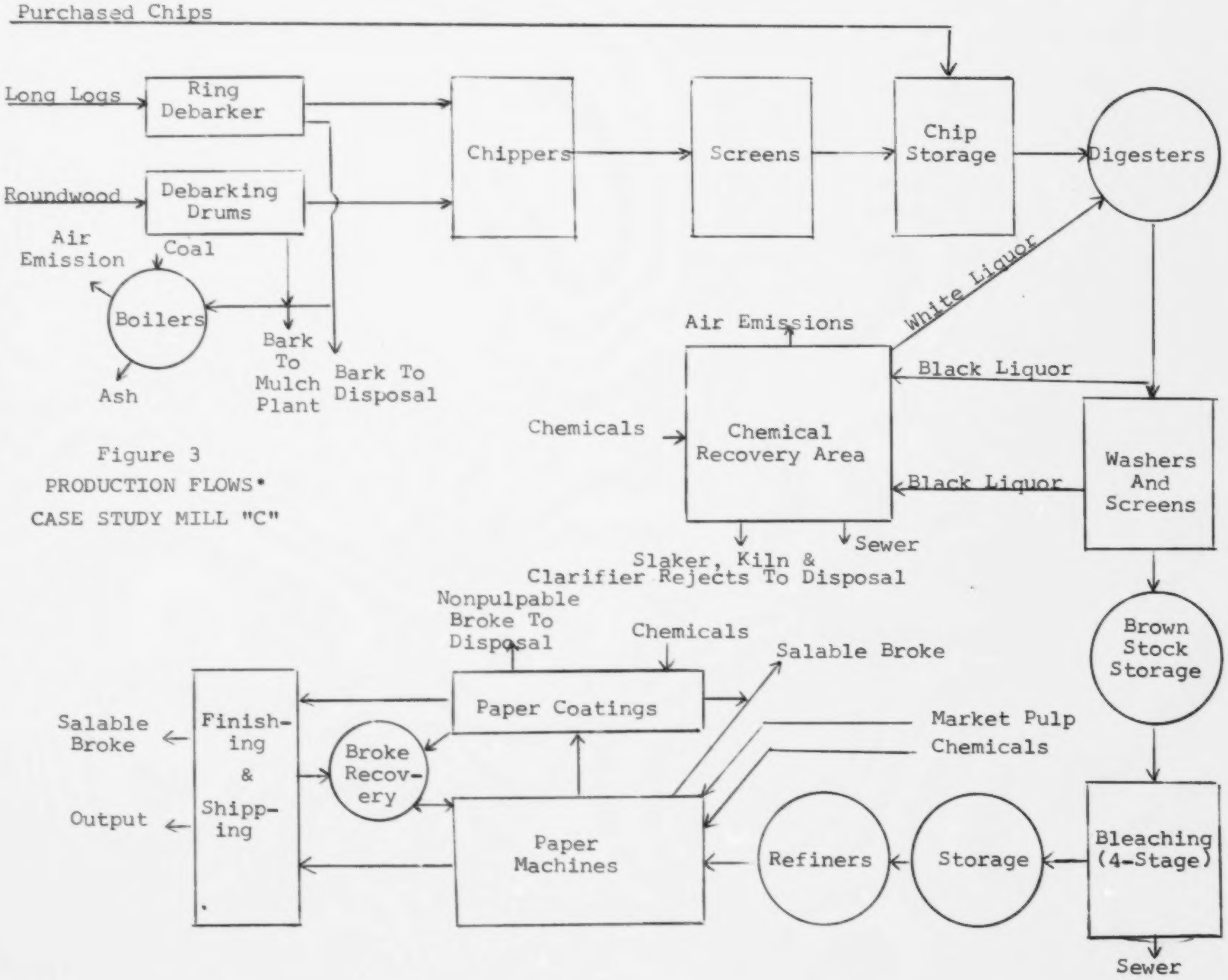
Purchased Chips
Long Logs
Ring Debarker
Roundwood
Debarking Drums
Air Emission
Coal
Boilers
Ash
Bark To Mulch Plant
Bark To Disposal
Chippers
Screens
Chip Storage
Digesters
White Liquor
Air Emissions
Black Liquor
Chemicals
Chemical Recovery Area
Black Liquor
Washers And Screens
Sewer
Slaker, Kiln & Clarifier Rejects To Disposal
Nonpulpable Broke To Disposal
Chemicals
Salable Broke
Brown Stock Storage
Salable Broke
Finishing & Shipping
Paper Coatings
Market Pulp
Chemicals
Broke Recovery
Output
Paper Machines
Refiners
Storage
Bleaching (4-Stage)
Sewer

Figure 3
PRODUCTION FLOWS*
CASE STUDY MILL "C"

*From Mill And Case Study Data

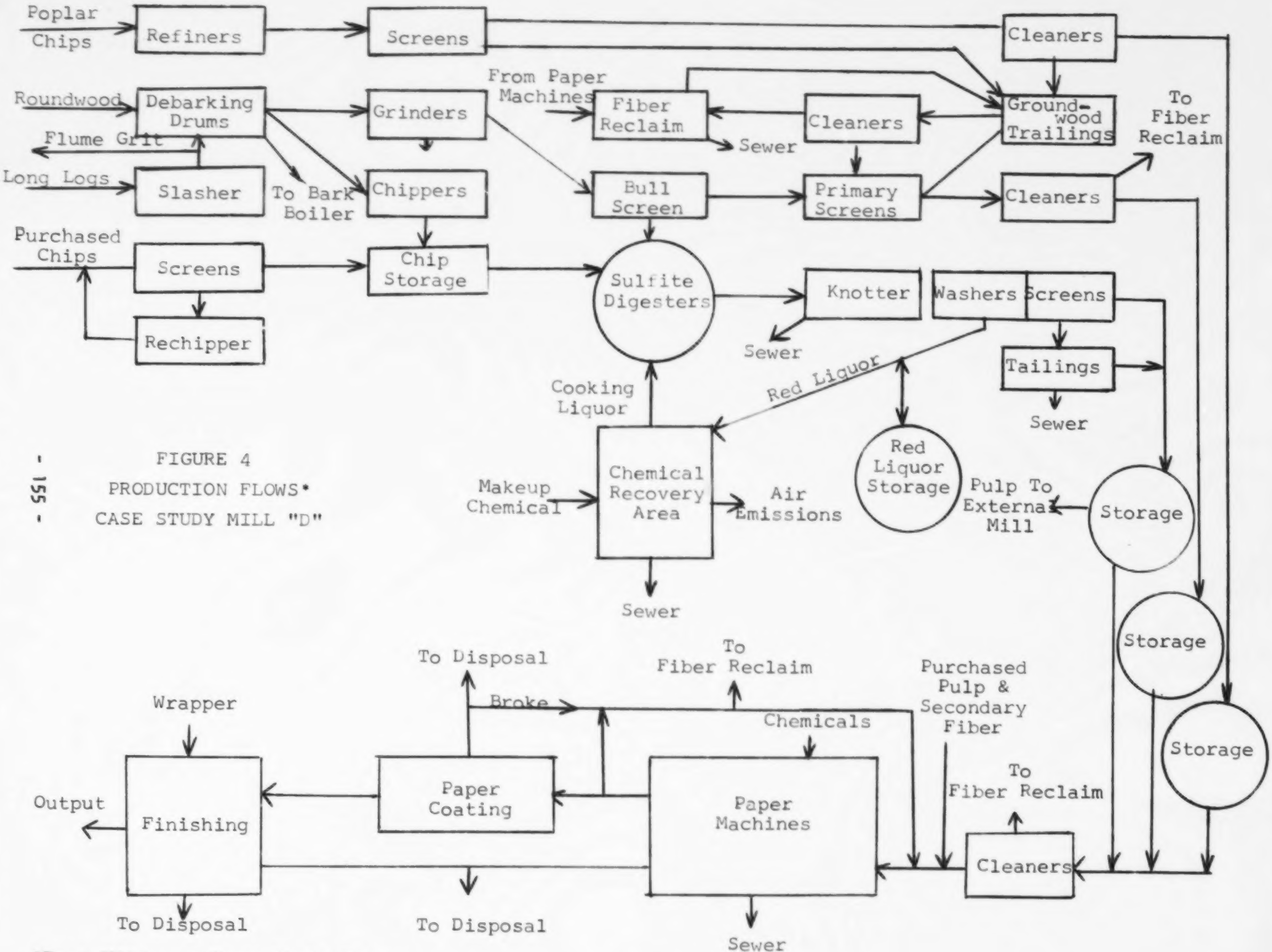
Poplar Chips
Refiners
Screens
Cleaners
Roundwood
Debarking Drums
Flume Grit
Long Logs
Slasher
To Bark Boiler
Grinders
Chippers
Purchased Chips
Screens
Rechipper
Chip Storage
From Paper Machines
Fiber Reclaim
Sewer
Cleaners
Ground-wood Trailings
To Fiber Reclaim
Bull Screen
Primary Screens
Cleaners
Sulfite Digesters
Knotter
Washers
Screens
Sewer
Tailings
Sewer
Red Liquor
Cooking Liquor
Red Liquor Storage
Makeup Chemical
Chemical Recovery Area
Air Emissions
Sewer
Pulp To External Mill
Storage
Storage
Storage
To Disposal
Broke
To Fiber Reclaim
Chemicals
Purchased Pulp & Secondary Fiber
To Fiber Reclaim
Wrapper
Output
Finishing
Paper Coating
Paper Machines
Cleaners
To Disposal
To Disposal
Sewer

FIGURE 4
PRODUCTION FLOWS*
CASE STUDY MILL "D"

*From Mill and Case Study Data

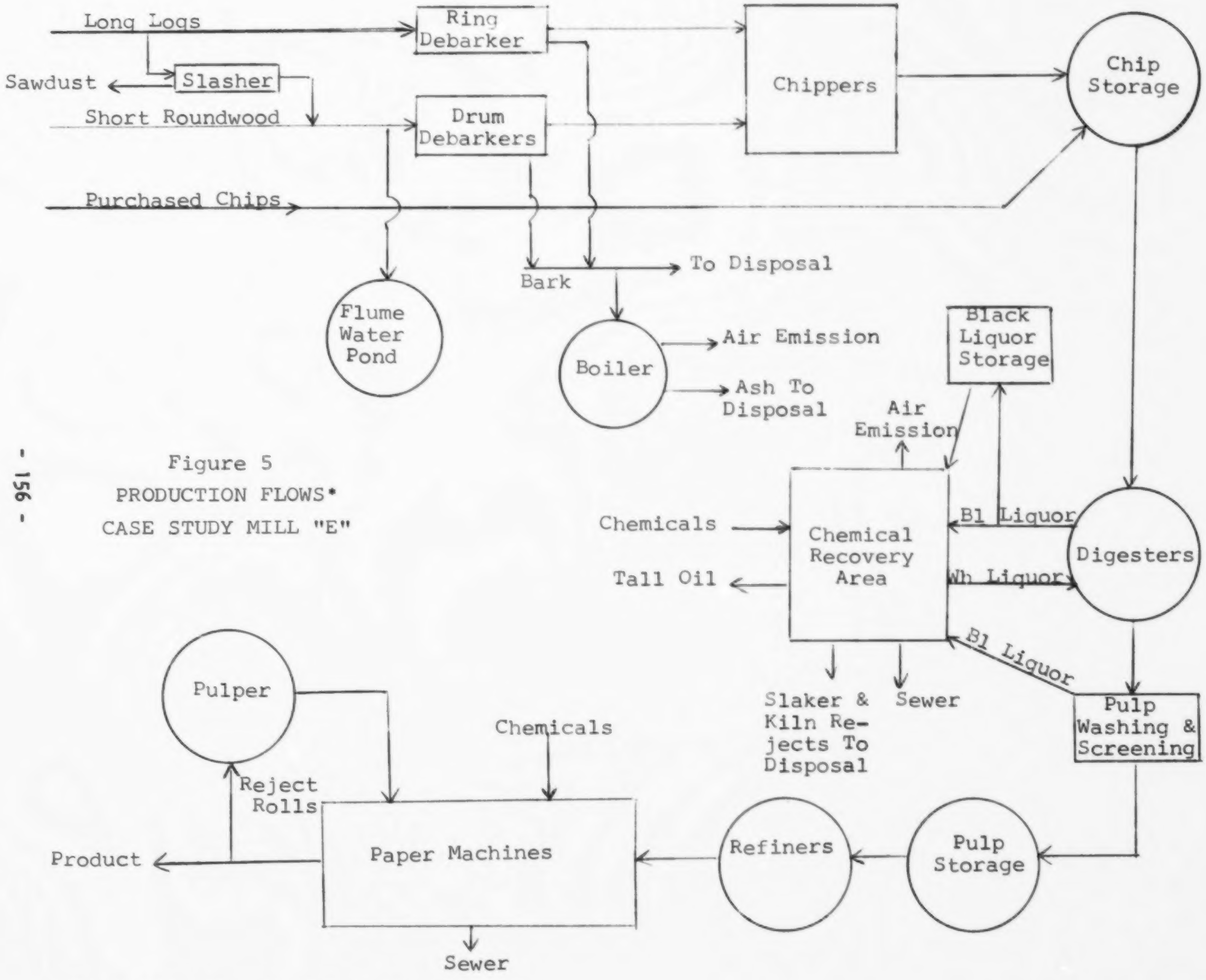
Long Logs
Sawdust
Slasher
Short Roundwood
Purchased Chips
Ring Debarker
Drum Debarkers
Chippers
Chip Storage
Flume Water Pond
Bark
To Disposal
Boiler
Air Emission
Ash To Disposal
Black Liquor Storage
Air Emission
Chemicals
Tall Oil
Chemical Recovery Area
Bl Liquor
Wh Liquor
Digesters
Bl Liquor
Slaker & Kiln Rejects To Disposal
Sewer
Pulp Washing & Screening
Pulper
Reject Rolls
Chemicals
Product
Paper Machines
Sewer
Refiners
Pulp Storage

Figure 5
PRODUCTION FLOWS*
CASE STUDY MILL "E"

*From Mill Data And Case Study Data

Solid Waste Generation

As described in the solid waste generation sections, several major activities comprise the pulp and paper industry's major solid waste generation sources. Each case study mill generated total solid waste quantities in line with the unit operations employed by that industry sector. Total quantities for each mill (Table 3) indicate the principal solid waste generation points for case study mills. All weights presented are wet weight or actual weight transported to the disposal site or reuse area. Table 3 presents quantity data for all solid waste sources even though they may not presently be handled by the existing solid waste management system. For example, as explained elsewhere in the report, lagooned sludge and flyash lagooning were not considered as solid waste management operations for the purposes of this study.

Solid waste generation rate comparisons between mills are generally misleading because of the different solid waste and production characteristics and practices. Total generation per ton of production does present an interesting comparison among mills (Table 4). The major factors contributing to the overall solid waste generation rates are the wood yard solid waste handling procedures, wastewater treatment sludge handling system, and boiler fuel ash content. Additionally, the raw materials used, processing variations, and product line all contribute to variations in actual solid waste types and quantities.

Material Balances

To illustrate the magnitude of total solids lost in each case study mill's manufacturing operations, an approximate material balance for each mill's 1972 operation was constructed (Tables 5 thru 9). This time period was chosen to provide assessment over a sufficient length of time to minimize short term fluctuations. The production flows and material losses were developed based on the best possible information resulting from case study data, mill records, and Gorham International Inc. estimates.

TABLE 3

SOLID WASTE GENERATION* - 1972**

Solid Waste Source	"A" Metric Tons (Tons)	"B" Metric Tons (Tons)	"C" Metric Tons (Tons)	"D" Metric Tons (Tons)	"E" Metric Tons (Tons)
Wood Yard & Wood Room	24,485 (26,997)		34,768 (38,333)	164,061 (180,884)	41,587(9) (45,852)(9)
Nonrecovery Boilers	19,809 (21,840)	20,566(1) (22,675)(1)	44,706 (49,290)		1,351 (1,490)
Recovery System	5,624 (6,200)		2,358 (2,600)		5,227 (5,762)
Pulping Systems	189 (208)			653 (720)	
General Refuse	2,075 (2,288)	577(2) (636)(2)	422 (465)	2,920 (3,217)	758 (835)
Water Treatment Sludge	NA NA	2,250(3) (2,481)(3)			
Primary Wastewater Treatment Sludge	NA NA	22,945(4) (25,298)(4)	113,629(6) (125,280)(6)	(8) (8)	NA NA
Wastepaper Processing		27,108 (29,888)			
Solid Waste To External Disposal		250(5) (276)(5)	NA		
Nonrecoverable Wastepaper		109 (120)	1,048 (1,155)	8,163 (9,000)	
Total Solid Waste To Disposal	52,182 (57,533)	73,805 (81,374)	196,931 (217,123)	175,797 (193,821)	48,923 (53,939)

(Continued On Next Page)

TABLE 3

(Continued)

Solid Waste Source	"A" Metric Tons (Tons)	"B" Metric Tons (Tons)	"C" Metric Tons (Tons)	"D" Metric Tons (Tons)	"E" Metric Tons (Tons)
Bark Consumption - Boilers***	169,173 (186,519)		14,732 (16,243)	21,632 (28,849)	88,730 (97,828)
Bark To Other Uses			8,321(7) (9,174)(7)		
Salvaged Materials Sold	466 (514)	100 (110)	838 (924)	918 (1,012)	499 (550)
Wastepaper Sold			20,775 (22,905)		
Total Solid Waste Recovered****	169,639 (187,033)	100 (110)	44,666 (49,246)	22,550 (29,861)	89,229 (98,378)
Total Solid Waste Generation****	221,821 (244,566)	73,905 (81,480)	241,597 (266,369)	198,347 (223,682)	138,152 (152,317)

(Continued On Next Page)

TABLE 3

(Continued)

Footnotes

(1) Includes Lagooned Flyash From Air Pollution Control Devices

(2) Includes 218 Metric Tons (240 Tons) To Air Curtain Destructor

(3) Lagooned With Flyash

(4) To Sludge Lagoons

(5) Cafeteria And Other Food Waste

(6) To Land Disposal

(7) To Mulch Plant

(8) Primary Treatment Started In 1973 With Sludge Incinerator In Use

(9) Includes Grit Going To Grit Pond From Log Flumes

*All Weights Expressed In Wet Weight (Weight Actually Handled)

**From Case Study Data

***Combustion Loss (Total Bark To Boilers Minus Ash - Ash Included In Nonrecovery Boiler Solid Waste)

****Excludes Recovered Broke Because Of Extreme Variations In Availability of Valid Data

NA - Not Available

TABLE 4

TOTAL SOLID WASTE TO DISPOSAL*

Mill	Kg Per Bone-Dry Metric Ton of Production (Lb Per Bone-Dry Ton of Production)
A	181 (361)
B	136 (271)
C	755 (1,510)
D	498 (995)
E	502 (1,003)

*From Case Study Data

TABLE 5

APPROXIMATE MATERIAL BALANCE - 1972*
CASE STUDY MILL "A"

Input
Metric Tons/Yr
(Tons/Yr)

Wood	Wet	Dry
Roundwood		410,101 (452,151)
Bark		87,168 (96,106)
Sawdust	90,955 (100,281)	54,573 (60,169)
Shavings	38,410 (42,348)	23,046 (25,409)
Chips		64,766 (71,407)
Total		639,654 (705,242)
Grit-River Mud		**Dry**
Wood Yard		6,314 (6,961)
Log Flume		7,124 (7,854)
Total		13,438 (14,815)

Output
Metric Tons/Yr
(Tons/Yr)

Wood Yard	Wet	Dry
Residuals Refuse	189 (208)	122 (135)
Wood Yard Refuse	7,264 (8,008)	3,632 (4,004)
Flume Clarifiers	17,034 (18,781)	8,007 (8,828)
Total		11,761 (12,967)
Bark Boilers		**Dry**
Bark Ash		1,637 (1,805)
Coal Ash		11,220 (12,370)
Coal Clinkers		189 (208)
River Mud		6,759 (7,452)
Stack		365 (402)
Total		20,170 (22,237)

TABLE 5
(Continued)

Fuel	Dry
Coal	118,223 (130,345)
Total	118,223 (130,345)

Chemicals	Dry
Pulping	35,468 (39,105)
Bleaching	51,237 (56,491)
Papermaking	19,676 (21,694)
Total	106,381 (117,290)

Paper Machine	Dry
Machine Broke	8,773 (9,672)
Converting Broke	9,313 (10,268)
Baled Pulp	22,400 (24,697)
Total	40,486 (44,637)

Kraft Pulping	Wet	Dry
M&D Digester	189 (208)	123 (135)
Brown Stock Screens		1,129 (1,245)
Pulping Chemicals		9,956 (10,977)
Total		11,208 (12,357)

Chemical Recovery	Dry
Lime Slakers	3,973 (4,380)
Lime Kiln Lumps	1,651 (1,820)
Lime Mud	2,785 (3,071)
Lime Kiln Stack	879 (969)
Recovery Stack	3,432 (3,784)
Smelt Tank (Air)	747 (824)
Green Liquor Dregs	2,897 (3,194)
Misc. Air Emission	1,576 (1,738)
Total	17,940 19,780)

TABLE 5
(Continued)

Bleach Plant	Dry
Spent Chemicals	85,731 (94,522)
Total	85,731 (94,522)

Paper Mill	Dry
Sewer Losses	26,693 (29,430)
Total	26,693 (29,430)

Combustion Losses	Dry
Bark	80,206 (88,430)
Coal	106,814 (117,767)
Black Liquor	208,280 (229,636)
Total	395,300 (435,833)

TABLE 5
(Continued)

GRAND TOTAL	918,182 (1,012,329)

Production	Dry
Tall Oil	5,925 (6,533)
Turpentine	392 (432)
Paper & Board	289,041 (318,678)
Baled Pulp	53,963 (59,496)
Inventory Increase	58 (64)
	349,379 (385,203)
GRAND TOTAL	918,182 (1,012,329)

*From Case Study Data, Mill Data, and Gorham International Inc.

TABLE 6

APPROXIMATE MATERIAL BALANCE - 1972*

CASE STUDY MILL "B"

Input
Metric Tons/Yr
(Tons/Yr)

Fiber Supply	Wet	Dry
Chips	171,105 (188,649)	102,662 (113,189)
Wastepaper	191,216 (210,823)	177,831 (196,065)
Broke		4,245 (4,680)
Total		284,738 (313,934)
Chemicals		**Dry**
NSSC Pulping		16,054 (17,700)
Deinking		482 (531)
Papermaking		12,800 (14,113)
Coating		1,280 (1,411)
Total		30,616 (33,755)

Output
Metric Ton/Yr
(Tons/Yr)

NSSC Pulping	Wet	Dry
Sewer Loss		41,621 (45,889)
Total		41,621 (45,889)
Wastepaper Stock Prep		**Dry**
Solid Waste (Rejects)		27,108 (29,888)
Sewer Loss		136 (150)
Total		27,244 (30,038)
Paper Mill		**Dry**
Sewer Loss		21,702 (23,927)
Nonrecoverable Broke		109 (120)
Total		21,811 (24,047)

TABLE 6
(Continued)

Fuel	Dry
Coal	174,605 (192,508
Total	174,605 (192,508)
GRAND TOTAL	489,959 (540,197)

Power Boilers	Wet	Dry
Ash (Landfill)		2,701 (2,978)
Flyash (Flyash Pond)		17,865 (19,697)
Air Emissions		386 (426)
Combustion Losses		153,652 (169,407)
Total		174,604 (192,508)
Production	**Wet**	**Dry**
Paperboard	241,589 (266,360)	224,677 (247,715)
Total		224,677 (247,715)
GRAND TOTAL		489,959 (540,197)

*From Case Study Data, Mill Data, and Gorham International Inc.

TABLE 7

APPROXIMATE MATERIAL BALANCE - 1972*

CASE STUDY MILL "C"

Input
Metric Tons/Yr
(Tons/Yr)

Wood	Wet	Dry
Roundwood	305,747 (337,097)	183,448 (202,258)
Chips		135,235 (149,102)
Bark, Grit, Etc.	57,961 (63,904)	27,242 (30,035)
Total		345,925 (381,395)
Fuel		**Dry**
Coal		319,228 (351,960)
Total		319,228 (351,960)

Output
Metric Tons/Yr
(Tons/Yr)

Wood Yard	Wet	Dry
Bark & Grit To Mulch Plant	8,321 (9,174)	3,911 (4,312)
Bark & Grit To Disposal Site	34,768 (38,333)	16,350 (18,027)
Total		20,261 (22,339)
Boilers	**Wet**	**Dry**
Wet Ash	15,026 (16,567)	7,513 (8,283)
Dry Ash		27,969 (30,837)
Clinkers		1,712 (1,887)
Air Emissions		20,407 (22,500)
Total		57,601 (63,507)

TABLE 7

(Continued)

Chemicals	Dry
Pulping	18,382 (20,267)
Bleaching	22,265 (24,548)
Paper Mill & Coating	93,607 (103,205)
Total	134,254 (148,020)

Paper Machines	Wet	Dry
Market Pulp	97,456 (107,459)	87,719 (96,713)
Total		87,719 (96,713)

Kraft Pulping & Chemical Recovery	Dry
Dregs, Slaker & Kiln Rejects	2,358 (2,600)
Air Emissions (Particulate)	3,207 (3,536)
Liquid Effluent	69,425 (76,543)
Total	74,990 (82,679)

Bleaching	Dry
Liquid Effluent	35,521 (39,163)
Total	35,521 (39,163)

TABLE 7

(Continued)

GRAND TOTAL	887,126 (978,088)

Paper Mill & Coating	Wet	Dry
Liquid Effluent		50,133 (55,273)
Unusable Broke To Disposal Site	1,048 (1,155)	995 (1,097)
Broke Sold As Wastepaper	20,775 (22,905)	19,736 (21,760)
Total		70,864 (78,130)
Combustion Losses		**Dry**
Coal & Bark		268,607 (296,149)
Black Liquor		98,404 (108,494)
Total		367,011 (404,643)
Production	**Wet**	**Dry**
Paper	260,898 (287,649)	247,853 (273,267)
Market Pulp	14,471 (15,955)	13,025 (14,360)
Total		260,878 (287,627)
GRAND TOTAL		887,126 (978,088)

*From Case Study Data, Mill Data, and Gorham International Inc.

TABLE 8

APPROXIMATE MATERIAL BALANCE - 1972*

CASE STUDY MILL "D"

Input
Metric Tons/Yr
(Tons/Yr)

Wood	Wet	Dry
Poplar Chips	25,996 (28,660)	12,998 (14,330)
S.W. Chips	139,420 (153,710)	69,710 (76,855)
Roundwood		534,512 (589,300)
Total		617,220 (680,485)
Chemicals		**Dry**
Pulping		15,651 (17,255)
Paper Machines & Coating		33,115 (36,509)
Total		48,766 (53,764)

Output
Metric Tons/Yr
(Tons/Yr)

Wood Yard	Wet	Dry
Bark Pumped To Landfill	78,482 (86,526)	39,241 (43,263)
Bark Hauled To Landfill	78,482 (86,526)	39,241 (43,263)
Slasher Sawdust	1,226 (1,352)	613 (676)
Flume Grit	5,878 (6,480)	2,939 (3,240)
Total		82,034 (90,442)
Boilers		**Dry**
Bark Ash		328 (361)
Total		328 (361)

TABLE 8
(Continued)

Paper Machines	Wet	Dry
Purchased Kraft	22,393 (24,688)	21,049 (23,207)
Directories	246 (271)	231 (255)
Waste Kraft	796 (878)	748 (825)
Total		22,028 (24,287)

Shipping	Wet	Dry
Purchased Wrap	973 (1,073)	915 (1,009)
Total		915 (1,009)

Groundwood Pulping System	Wet	Dry
Bull Screens		2,939 (3,240)
Shives	654 (720)	327 (360)
Fiber Reclaim Sewer		13,136 (14,482)
Total		16,402 (18,082)

Sulfite Pulping System	Dry
Knotters	3,396 (3,744)
Trailings	1,002 (1,105)
Air Emissions - Nonrecovery	776 (855)
Air Emissions - Recovery	667 (735)
Liquid Effluent	10,118 (11,155)
Total	15,969 (17,594)

TABLE 8
(Continued)

GRAND TOTAL	688,929 (759,545)

Paper Mill & Coating	Dry
Broke To Landfill	8,163 (9,000)
Liquid Effluent	16,360 (18,037)
Total	24,523 (27,037)
Combustion Losses	Dry
Bark	11,253 (11,684)
Red Liquor	182,914 (202,400)
Total	194,167 (214,084)
Production	Dry
Paper	267,683 (295,120)
Market Pulp	85,588 (94,361)
Liquor Loss With Pulp	2,235 (2,464)
Total	355,506 (391,945)
GRAND TOTAL	688,929 (759,545)

*From Case Study Data, Mill Data, and Gorham International Inc.

TABLE 9

APPROXIMATE MATERIAL BALANCE - 1972*

CASE STUDY MILL "E"

Input
Metric Tons/Yr
(Tons/Yr)

Wood	Wet	Dry
Roundwood	803,438 (885,820)	401,719 (442,910)
Bark	136,752 (150,774)	68,376 (75,387)
Chips	216,962 (239,208)	108,481 (119,604)
Total		578,576 (637,901)

Chemicals	Dry
Pulping	35,621 (39,273)
Tall Oil Acid	3,362 (3,707)
Papermaking	4,145 (4,570)
Lime	5,278 (5,819)
Total	48,406 (53,369)

Output
Metric Tons/Yr
(Tons/Yr)

Wood Yard	Wet	Dry
Wood Yard Refuse	36,504 (40,248)	18,252 (20,124)
Grit Pond		5,083 (5,604)
Total		23,335 (25,728)

Power Boilers	Dry
Bark Ash	1,351 (1,490)
Stack	533 (588)
Total	1,884 (2,078)

TABLE 9

(Continued)

Chemical Recovery	Dry
Lime Slakers	3,866 (4,262)
Lime Kiln Lumps	1,361 (1,500)
Black Liquor Pond	6,484 (7,149)
Lime Kiln Stack	52 (57)
Recovery Stack	1,980 (2,183)
Sewer	24,805 (27,349)
Total	38,548 (42,500)

Paper Mill	Dry
Sewer Losses	7,913 (8,724)
Total	7,913 (8,724)

TABLE 9
(Continued)

GRAND TOTAL	626,982 (691,270)

Combustion Losses		Dry
Bark		43,156 (47,581)
Black Liquor		233,502 (257,444)
Total		276,658 (305,025)
Production	**Wet**	**Dry**
Tall Oil		11,732 (12,935)
Linerboard	280,960 (309,768)	266,912 (294,280)
Total		278,644 (307,215)
GRAND TOTAL		626,982 (691,270)

*From Case Study Data, Mill Data, and Gorham International Inc.

The air losses and waterborne losses from each mill are handled by different treatment methods and represent approximate values for final discharges. Without an in depth study of sewer flows and existing wastewater treatment operations, discussion of specific raw waste loads and final effluent characteristics would not be appropriate. The solids losses indicated as sewer losses included suspended solids, dissolved organic solids, and dissolved inorganic solids. This study did not attempt to distinguish between these losses or to assess the effluent quality resulting from existing treatment processes.

Overall, these material balances present information to illustrate the quantities of material handled in typical pulp and paper industry operations and to point out where typical solids losses occur.

Solid Waste Management Systems

Each case study mill operated an internal solid waste management system to remove solid waste from generation points to disposal areas. While many similarities existed each mill's system had unique characteristics. This section will present a brief discussion of each mill's solid waste management operational procedures.

Case Study Mill "A". The solid waste management system at this mill is operated entirely by mill personnel and is confined to on-site operations, except for the transport of cafeteria solid waste to a county disposal site. The general solid waste collection system consists of a "Heil Huge Haul" container system. Roll-on-roll-off containers varying in size from 6.1 to 30.6 cubic meters (8 to 40 cubic yards) are used to collect solid waste from mill premises. Solid waste is transferred from internal generation points to these containers by the janitorial staff. At the shipping dock where both shipping and converting solid waste are deposited, a stationery compactor is used to obtain volume reduction. The container carrying truck is also used to carry the cafeteria solid waste to the county disposal site. Containers are in use to transport scrap metal from the shop and used drums to the salvage area.

To collect larger solid waste sources, a front-end loader and dump truck combination is employed. These pick ups occur at the sawdust digester, recovery area, flume water clarifiers, residuals storage area, and for the general wood yard cleanup. These trucks also collect miscellaneous litter drums placed on mill premises. An additional truck is used to transfer ashes from the ash hopper to the disposal site.

The disposal site is located on mill property and receives all solid waste except from the cafeteria. Material is dumped from the edge of the fill over the side embankments. No definite plan is followed and much exposed corrugated is visible on the side slopes. Also, standing water exists at the base of the side slopes in several locations.

This mill operates a salvage yard to reclaim material (primarily metals) for internal reuse and sale. Additionally, major efforts are undertaken to recycle paper machine and converting operation broke to the process. Bark from the debarking drums is processed through bark hogs, is stored in an "Atlas" bin, and is burned for its fuel value.

Case Study Mill "B". This mill's solid waste management system consists of both company operated and contracted portions. The company operated portion consists of a "Dempster Dumpster" type of container system used to transport process solid waste to the company's disposal site. Dump trucks are also used to transport material to the air curtain destructor used for volume reduction of nonpulpable broke and bulky combustibles (pallets, fiber drums, etc.)

Movement of solid waste from generation points to containers is generally performed by the production personnel responsible for the waste generation activity or by continuous conveyors. Dump trucks and front-end loaders are also used to transport dry ashes and ashes from the flyash lagoon. Because it is an industrial disposal site, the state authorizes ashes to be used as cover material. Filled land is then used for wastepaper inventory space and other yard activities. Because of the high percentage of inert materials (wastepaper contamination) little blowing litter or other unsightly conditions were visible at the disposal site.

The contractor system uses containers to collect all personnel waste that contains cafeteria and lunch area solid waste. This material is transported to a licensed sanitary landfill external to mill property.

This mill's resource recovery activities are limited to a salvage yard plus efforts to maximize fiber utilization and eliminate solids losses in mill sewers and through the wastewater treatment plant.

Case Study Mill "C". This solid waste management system is entirely internal except for the cafeteria that has a private contract for food wastes and a contract to assist in hauling miscellaneous solid wastes. The company operated "Dempster Dumpster" type container system collects general refuse transferred to the outside containers by janitors and production personnel. A dump truck is used to transport ashes, recovery area solid waste, wood yard debris, and miscellaneous material to the disposal site. Part of the ash is collected dry in an ash silo while part is transported by water to a small settling basin with settled material removed by a crane. All the above solid waste is transported to a company owned disposal site where final earth cover is planned. A separate disposal site is utilized for primary wastewater treatment sludge with the sludge deposited and periodically spread to obtain maximum natural dewatering. Both disposal sites exhibited no objectionable odors or other noticeable aesthetic problems.

This mill employs major resource recovery activities including burning of some bark as fuel, supplying bark to a mulch plant, selling difficult to reuse broke in the wastepaper market, operating a salvage yard, and more recently, supplying bark to a feedlot as bedding material.

Case Study Mill "D". Operated entirely by mill personnel and internal to the mill property, the basic collection methods consist of a "Dempster Dumpster" container system and dump trucks. Containers are used for miscellaneous solid waste plus specific wastes from relatively small generation sources. During 1972, the transportation of bark to the disposal site was changed from a continuous pipeline to truck transportation. This step was taken as the mill changes over to dry debarking with subsequent combustion of large portions of the waste bark. Dump trucks are also used to transport primary sludge incinerator residue, wood yard debris, slasher sawdust, and paper mill and coating area wastepaper and trash.

Disposal site operations are difficult to control and manage with the large bark quantities currently entering the site. However, the new bark burning system should materially improve disposal site operations.

Current resource recovery operations are focused on the bark burning system. Additional attention is being addressed to making interconnections to maximize overall yield from the three pulping systems. Also, a typical salvage yard represents a resource recovery activity.

Case Study Mill "E". Similar to other mills, a mill operated "Dempster Dumpster" type removable container system transports solid waste to the mill's private disposal site. Mill janitors transport solid waste from internal storage to the removable containers. Also, a dump truck and front-end loader transport miscellaneous solid waste and wood yard debris to disposal. The mill cafeteria is operated by a private contractor who arranges for his own solid waste disposal off mill premises.

The mill disposal site is characterized by random dumping spots and no working plan. However, because of its remote shielded location, no nuisance conditions appear to exist.

Resource recovery operations consist primarily of bark burning with construction underway to enable more complete use of wood yard solid waste and slasher sawdust as fuel. Also, a salvage yard operation enables recovery and sale of reusable materials.

Economic Considerations

The major economic considerations for the case study mills resulted from the external collection system (container systems and dump trucks). Internal collection and disposal represented less costs and generally involved fewer people.

The cost per ton of material to disposal (Table 10) and per unit of production (Table 11) provide interesting comparisons from company to company. The presented costs include all the costs associated with the solid waste management operations except for resource recovery costs. Because so much of the resource recovery efforts are fully integrated with the production function, only portions of the required data were accessible. Thus, no comparisons were included in this case study summary. The basic differences resulted from the volumes and types of solid waste handled, the number of point sources, and the complexity of the operations. Overall, these mills provide reasonable solid waste management service at much lower costs than most municipal or other industrial solid waste management operations.

TABLE 10

SOLID WASTE MANAGEMENT SYSTEM TOTAL COSTS - 1972*

	Mill "A" Total Cost	Mill "A" Cost/Metric Ton To Disposal	Mill "A" Cost/Ton To Disposal	Mill "B" Total Cost	Mill "B" Cost/Metric Ton To Disposal	Mill "B" Cost/Ton To Disposal
LABOR						
Internal Collection	$369,283	$ 7.08	$6.42	$ 49,200	$1.63	$1.48
External Collection	82,056	1.57	1.43	29,116	0.96	0.87
Disposal	NA	NA	NA	4,860	0.17	0.15
Subtotal (Labor)	$451,339	$ 8.65	$7.85	$ 83,176	$2.76	$2.50
EQUIPMENT						
Internal Collection	$ 5,870	$ 0.11	$0.10	$ 2,000	$0.07	$0.06
External Collection	100,963	1.94	1.75	55,776	1.84	1.67
Processing				1,700	0.05	0.05
Disposal				6,750	0.22	0.20
Subtotal (Equipment)	$106,833	$ 2.05	$1.05	$ 66,226	$2.18	$1.98
TOTAL COMPANY OPERATIONS	$558,172	$10.70	$9.70	$149,402	$4.94	$4.48

(Continued On Next Page)

TABLE 10
(Continued)

	Mill "C" Total Cost	Mill "C" Cost/Metric Ton To Disposal	Mill "C" Cost/Ton To Disposal	Mill "D" Total Cost	Mill "D" Cost/Metric Ton To Disposal	Mill "D" Cost/Ton To Disposal
LABOR						
Internal Collection	$145,128	$0.74	$0.67	$141,233	$0.80	$0.73
External Collection	145,916	0.74	0.67	220,060	1.25	1.13
Disposal	6,203	0.03	0.03	46,359	0.27	0.24
Subtotal (Labor)	$297,247	$1.51	$1.37	$407,652	$2.32	$2.10
EQUIPMENT						
Internal Collection	$ 250	$0.00	$0.00			
External Collection	302,897	1.54	1.39			
Disposal	8,197	0.04	0.04	$354,886	$2.02	$1.83
Leased Equipment	19,242 (2)	0.10	0.09	43,680	0.25	0.23
Subtotal (Equipment)	$330,586	$1.68	$1.52	$398,566	$2.27	$2.06
TOTAL COMPANY OPERATIONS	$627,833	$3.19	$2.89	$806,218	$4.59	$4.16

(Continued On Next Page)

TABLE 10

(Continued)

		Mill "E"	
	Total Cost	Cost/Metric Ton To Disposal	Cost/Ton To Disposal
LABOR			
Internal Collection	$ 12,783	$0.29	$0.26
External Collection	63,630	1.45	1.32
Disposal	1,123	0.03	0.02
Subtotal (Labor)	$ 77,536	$1.77	$1.60
EQUIPMENT			
External Collection	$ 58,365	$1.33	$1.21
Disposal	1,800	0.04	0.04
Subtotal (Equipment)	$ 60,165	$1.37	$1.25
TOTAL COMPANY OPERATIONS	$137,701	$3.14	$2.85

(2) For External Collection

*From Case Study Data

TABLE 11

SOLID WASTE MANAGEMENT COSTS ON PRODUCTION BASIS*

Mill	$/Bone Dry Metric Ton Of Production	$/Bone Dry Ton Of Production
A	$1.93	$1.75
B	0.65	0.63
C	2.41	2.18
D	2.28	2.07
E	0.52	0.47

μσ825

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*From Case Study Data